THE INFLUENCE OF STRONG, PREVALENT, RAIN-BEARING WINDS ON THE PREVALENCE OF PHTHISIS

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WITH MAPS

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TO

THE MEMORY OF

MARCUS BECK, M.S., M.B., F.R.C.S.,

SOMETIME SURGEON TO UNIVERSITY COLLEGE HOSPITAL AND
PROFESSOR OF SURGERY IN UNIVERSITY COLLEGE, LONDON

TO WHOM HE OWES SO MUCH

THIS SMALL VOLUME

IS GRATEFULLY INSCRIBED

BY THE AUTHOR

The Edinburgh Geographical Institute

John Bartholomew & Co.

PREFACE

In the following pages I have put together, as briefly as possible, the evidence collected during the past ten years in favour of an influence of strong rain-bearing winds on the prevalence of phthisis. So presented it can be more easily examined than in disconnected papers.

The subject is one which has seemed to me to justify the time and labour—not inconsiderable—which have been spent upon it. If these winds have the influence which I have been led to assign to them, much of the climatology of phthisis will have to be reconsidered; indeed, there are already indications, in the evidence here submitted, of the changes of opinion which such a revision will necessitate. Its practical importance to those in whom phthisis has been arrested, and who are free to choose their future place of residence, is obvious.

In planning out each step of the work every precaution I could think of has been taken to avoid error, and in seeking for safeguards I have been much helped by the criticisms which have met each paper on its publication. To myself the proof, as it appears in these pages, seems conclusive. But others may find shortcomings where I have failed to discover them.

I desire to record my very great indebtedness to those whose invaluable help has been so generously given to me, *viz.* to Professor J. G. Adami, F.R.S., Montreal; the late Sir Hugh Adcock, C.M.G., Teheran, Persia; Dr. J. F. Allen, Natal Delegate to the British Congress on Tuberculosis,

1901, Bedford; Professor A. Angot, Chef de Service de la Climatologie, Paris; Mr. W. N. Beauclerk, British Consul-General at Lima, Peru; Dr. C. C. Brodrick, Medical Officer of Health, Tavistock; Mr. P. H. Bryce, Secretary to the Registrar-General, Ontario; Dr. E. Campodonico, Lima, Peru; Dr. F. G. Clemow, F.R.G.S., British Embassy, Constantinople; Dr. F. W. Clark, Hong-Kong; Dr. W. Colborne, Hakodaté, Japan; Dr. B. G. Corney, I.S.O. Suva, Fiji; Dr. R. Denman, Mahé, Seychelles Islands; the late Sir Joseph Fayrer, Bart., K.C.S.I.; Dr. N. S. Fraser, St. John's, Newfoundland; Dr. J. J. Grace, Hilo, Sandwich Islands; the Hon. S. Hamilton, F.R.C.S.I., President of the Board of Health, Falkland Islands; Mr. J. G. Hamling, Barnstaple; Dr. H. Handford, F.R.C.P., Medical Officer of Health for the County of Nottingham; Dr. J. R. Harper, Medical Officer of Health of Barnstaple; Dr. Harvey, late Medical Officer of Health, Newton Abbot; Dr. L. G. Hill, Pakhoi, S. China; Dr. M. Holmboë, Director of the Medical Service of Norway; Dr. H. Horrocks, Perth, West Australia; Dr. J. C. Hoyle, late Medical Officer of Health of Rangoon, Upham; Dr. W. Huggard, F.R.C.P., Davos Platz; Dr. B. R. Johnston, Grasmere; Sir Alfred Keogh, K.C.B., Director-General, A.M.S.; Mr. W. A. King, Chief Statistician, Bureau of the Census, Washington; Dr. W. H. Lowman, Dera Ismail Khan, India; Sir W. MacGregor, K.C.M.G., C.B., Governor of Queensland, late Governor of Lagos; Dr. J. L. Maxwell, Tainan, Formosa; Dr. A. Neve, Srinagar, Kashmir; Dr. Elzéar Pelletier, Secretary, Board of Health of the Province of Quebec; Dr. A. C. Rodriquez, Medical Officer of Health, Campo, Azores; Dr. H. Rördam, Chief Physician of the First Class of Naval Marine, Copenhagen; Dr. E. J. Slade-King, Medical Officer of Health, Ilfracombe; Dr. G. Sprott, Hobart, Tasmania; Dr. J. Cleasby Taylor, Las Palmas, Grand Canary; Dr. W. Thomson, Mustapha, Algiers; Dr. D. C. Trott, Hamilton, Bermuda; Dr. J. G. E. Trotter, Ajaccio, Corsica; Mr. T. Wainwright, North Devon Athenæum, Barnstaple; Mr. W. J.

Wreford, Sanitary Inspector of Exeter, and Dr. E. H. Young, Medical Officer of Health of Okehampton.

How much I owe to them, and to those authors whose works I have very freely consulted, I have in some measure indicated by the references which will be found in the text. It is a regret to me that, for the sake of brevity, much that is interesting in the information supplied to me has had to be omitted.

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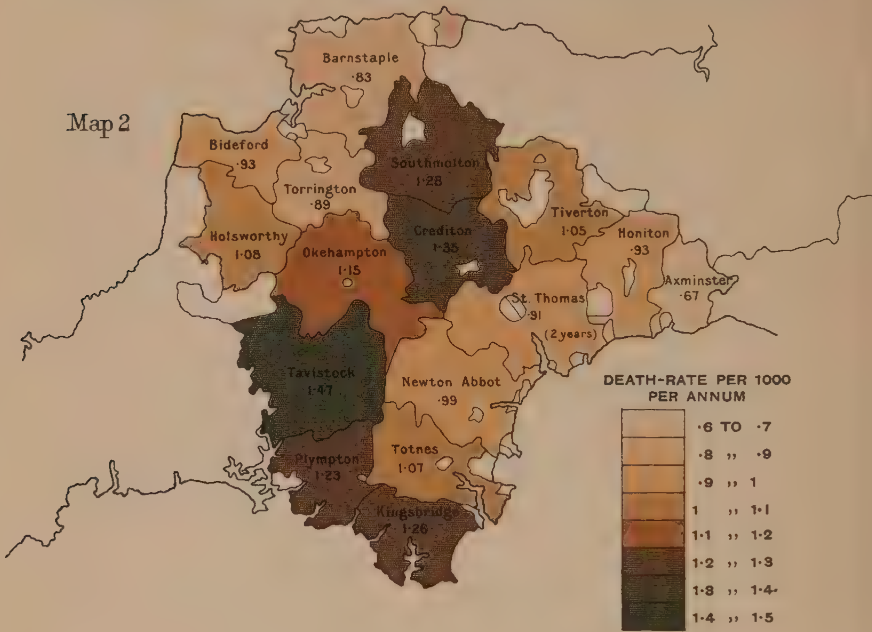

DEVONSHIRE
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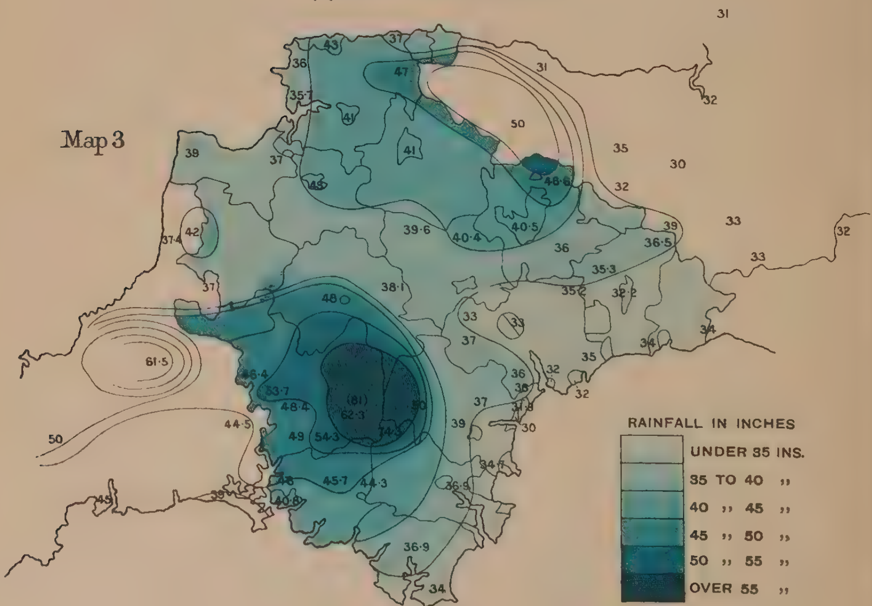
Map 3



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CHAPTER I

THE INFLUENCE OF WEST AND SOUTH-WEST WINDS ON PHTHISIS MORTALITY IN DEVONSHIRE

SUGGESTED BY THE DEATH-RATES OF THE RURAL DISTRICTS

IN the autumn of 1899, when the erection of a phthisis sanatorium near Exeter was under consideration, I examined the phthisis death-rates of the Rural Sanitary Districts of Devonshire, in the hope of finding facts which might help in the choice of a site for it. I chose the Rural Sanitary Districts rather than the Registration Districts because the latter included the Urban Districts, which seemed unlikely to present sufficiently uniform conditions of life, and are especially apt, in Devonshire, to introduce fallacy, because many of them have long been phthisis health-resorts, where imported cases are included in the death-returns.

My ideas were at that time those generally held, being in accordance with the views expressed by a well-known authority, that "the house should be protected from northerly and easterly winds, and well open to the south and west." My astonishment therefore was great to find that the ideally situated Districts, well open to south and west, were just those in which the phthisis mortality was highest (Map 2, Plate I).[1] I tried to explain this distribution of the death-rate by reference to general sanitation (as indicated by the mortality from all causes), to geology and to rainfall, and failed. Nothing except exposure to west and south-west winds seemed to offer a satisfactory explanation. But

[1] Compare also Map 1.

TABLE I

St. Thomas District. Influence of Shelter from W. and S.W. Winds and of Soil

Name of parish.	Estimated population 1900.	Phthisis deaths in $2\frac{1}{2}$ years.	Phthisis death-rate per 1,000 per annum.		
			All soils.	Pervious.	Impervious.
I. SHELTERED PARISHES (9), *i.e.* where the *dwellings* are sheltered from W. and S.W.:					
A. *On pervious soils*					
Kenn . . .	827	0			
Ashcombe . .	167	0			
Mamhead . .	158	0			
Ide	648	0			
	1,800	0			
B. *On impervious soils*					
Dunsford . .	665	0			
Bridford . .	429	1			
Christow . . .	567	1			
Doddiscombsleigh .	250	0			
Dunchideock . .	139	0			
	2,050	2			
	3,850	2	·24	Nil.	·41
II. EXPOSED PARISHES (18), *i.e.* where the *dwellings* are fully exposed *to W. or S.W., or both* :					
A. *On previous soils*					
Stoke Canon . .	363	1			
Huxham . .	111	1			
Topsham . .	2,833	10			
Pinhoe . . .	761	0			
Sowton . . .	450	0			
St. Mary's Clyst .	197	0			
St. George's Clyst .	291	0			
Woodbury . .	1,664	7			
Lympstone . .	1,097	3			
Whimple . .	656	2			
Aylesbeare . .	784	3			
Rockbeare . .	451	1			
Farringdon . .	215	1			
Otterton . .	725	4			
E. Budleigh . .	866	1			
Bicton . . .	121	1			
Colaton Raleigh .	567	3			
	12,152	38			
B. *On impervious soil*					
Tedburn St. Mary .	580	2			
	12,732	40	1·34	1·32	1·47

TABLE I—(*continued*)

Name of parish.	Estimated population 1900.	Phthisis deaths in 2½ years.	Phthisis death-rate per 1,000 per annum.		
			All soils.	Previous.	Impervious.
III. IMPERFECTLY SHELTERED PARISHES (17), *i.e.* where the *dwellings* are partly sheltered partly exposed as regards W. and S.W.:					
Whitstone . .	494	0			
Holcombe Burnell .	203	0			
Alphington . .	1,064	1			
Shillingford . .	66	0			
Exminster . .	2,337	3			
Powderham . .	203	0			
Clyst Hydon . .	298	1			
Clyst St. Lawrence .	126	0			
Broadclyst . .	2,003	2			
Honiton Clyst . .	274	1			
Rewe . . .	247	0			
Netherexe . .	70	0			
Upton Pyne . .	460	1			
Poltimore . .	361	0			
Brampford Speke .	350	0			
Ashton . . .	209	1			
Kenton . . .	1,901	4			
	10,666	14	·57	*	*

* As the degrees of exposure differ, these soils have not been compared.

this explanation was so contrary to my expectation that only a searching test could have convinced me of its validity.

BORNE OUT BY THE DEATH-RATES OF THE PARISHES IN FOUR SEPARATE RURAL DISTRICTS

This test was as follows. I took four Rural Sanitary Districts, two on the south coast of Devon (St. Thomas and Newton Abbot), one on the north coast (Barnstaple), one in mid-Devon (Okehampton), and examined the phthisis death-rates in the parishes of each separately. I chose parishes rather than larger units of area, because they allowed of more exact classification into "sheltered" and "exposed" as regarded wind, into "pervious" and "impervious" as regarded soil, and they enabled me to show more clearly, on maps of moderate size, the position of the dwellings. Soil

and rainfall were readily proved to be incapable of explaining the results. A comparison of maps tinted to show the distribution of the phthisis death-rate in the Districts, with maps of their geology, suggested no correspondence between phthisis mortality and soil and, in the single District where a satisfactory comparison was possible, no apparent influence of soil on phthisis prevalence was discernible, until the influence of wind-exposure was eliminated by comparing only sheltered parishes with sheltered, and exposed parishes with exposed (Table I). As the rainfall was generally heaviest in places where the phthisis death-rate was lowest, rainfall could scarcely be held to exercise an important adverse influence. Tables I, II, III, and IV give the figures for the four Districts, and Table V gives, for each, the phthisis death-rates per 1,000 per annum in the sheltered, exposed, and partly sheltered parishes respectively, with the period of observation and the approximate ratio between the mortalities in the exposed and in the sheltered parishes. In every one of these Rural Districts the same contrast came out between shelter and exposure.

In Table I the period of observation was too short for one to enter into the question of rarity of exception—although even here exception is less frequent than might have been expected. But in Tables II, III, and IV rarity of exception is quite distinct. In Newton Abbot District all the sheltered parishes have lower death-rates than all the exposed parishes. In Okehampton District all the sheltered parishes but one have lower death-rates than all the exposed parishes, and the one exceptional death-rate is not higher than that of any exposed parish. In Barnstaple District the exceptions are more numerous, but even there there are few.[1]

Whilst laying comparatively little stress on the figures from St. Thomas District, because the period of observation

[1] Here I would draw attention to a mistake which closer investigation of Barnstaple Rural District, with Dr. Harper's help, has enabled me to correct in the later work dealt with in Chapter V. Coombe Martin, Berrynarbor, Trentishoe, and Martinhoe, classed as "imperfectly sheltered" from west and south-west winds, should, Dr. Harper thinks—and I agree with him—have been classed as "sheltered." Of these it is seen that only Trentishoe, with a population of ninety-six persons, introduces further exception, and the ratio of exposed to sheltered only falls from 2·5 : 1 to 2 : 1.

TABLE II

Newton Abbot Rural District (*Influence of Shelter from W. and S.W. Winds*).

Name of parish.	Estimated population 1898.	Phthisis deaths in 15 years.	Phthisis death-rate per 1,000 per annum.
I. SHELTERED PARISHES (5):			
Ilsington . . .	1,000	10	·6
North Bovey . .	417	4	·6
Widecombe . .	744	10	·8
Lustleigh . . .	415	5	·8
Moreton Hampstead .	1,543	23	·9
Totals . .	4,130	52	Average ·83
II. EXPOSED PARISHES (7):			
Highweek . . .	2,540	39	1·0
Broadhempston . .	525	8	1·0
Kingsteignton . .	1,836	33	1·2
Bishopsteignton . .	1,085	24	1·4
Bickington . .	230	6	1·7
Ashburton . . .	2,762	75	(13 years, 65 deaths = 15 years, 75 deaths) 1·8
Teigngrace . .	170	6	2·3
Totals . .	9,148	191	Average 1·38
III. IMPERFECTLY SHELTERED PARISHES (17):			
Bovey Tracey . .	2,460	44	
Chudleigh . . .	2,003	23	
Kingskerswell . .	1,030	17	
Ipplepen . . .	824	17	
Dawlish Rural . .	715	20	
Hennock . . .	685	13	
Haccombe . . .	545	5	
Denbury . . .	516	10	
Stoke	511	10	
Abbotskerswell . .	431	5	
Manaton . . .	327	5	
Ogwell . . .	310	6	
Ideford . . .	286	1	
Coffinswell . . .	200	3	
Woodland . . .	184	1	
Trusham . . .	161	2	
Buckland . . .	71	1	
Totals . .	11,259	183	Average 1·08

TABLE III

Okehampton Rural District (Influence of Shelter from W. and S.W. Winds)

Name of parish.	Population 1891.	Phthisis deaths in 10 years.	Phthisis death-rate per 1,000 per annum.
I. SHELTERED PARISHES (7):			
Monkokehampton	191	0	0
Gidleigh	129	0	0
Ashbury	69	0	0
Inwardleigh	519	1	·2
Drewsteignton	751	5	·6
Chagford	1,460	12	·8
Throwleigh	281	3	1·0
Totals	3,400	21	Average ·61
II. EXPOSED PARISHES (11):			
Spreyton	388	4	1·0
Bridestowe	586	6	1·0
Broadwood Kelly	261	3	1·1
North Tawton	1,737	25	1·4
Beaworthy	268	4	1·4
Germansweek	211	4	1·9
Sourton	448	9	2·0
Sampford Courtenay	866	19	2·1
North Lew	714	16	2·2
Bratton Clovelly	487	11	2·2
Highampton	284	7	2·4
Totals	6,250	108	Average 1·72
III. IMPERFECTLY SHELTERED PARISHES (10):			
Meeth	203	1	
Iddlesleigh	377	4	
Hatherleigh	1,437	14	
Jacobstowe	222	6	
Exbourne	355	5	
Honeychurch	35	0	
Bondleigh	141	2	
Belstone	181	2	
South Tawton	1,264	19	
Okehampton (rural)	520	8	
Totals	4,735	61	Average 1·28

TABLE IV

Barnstaple Rural District (*Influence of Shelter from W. and S.W. Winds*)

Name of parish.	Population 1891.	Phthisis deaths in 10 years.	Phthisis death-rate per 1,000 per annum.
I. SHELTERED PARISHES (10):			
Bittadon	46	0	0
Kentisbury	344	0	0
Arlington	238	0	0
Brendon	294	0	0
Eastdown	346	1	·2
Westdown	562	2	·3
Challacombe	226	1	·4
Parracombe	318	2	·6
Tawstock	1,206	9	·7
Highbray	226	2	·9
Totals	3,806	17	Average ·44; ·52 corrected*
II. EXPOSED PARISHES (14):			
Horwood	108	0	0
Stoke Rivers	199	1	·5
Marwood	787	6	·7
Heanton Punchardon	449	4	·9
Morthoe	678	7	1·0
Pilton (rural)	555	7	1·0
Bratton Fleming	499	5	1·0
Braunton	2,171	26	1·1
Goodleigh	239	3	1·2
Georgeham	747	9	1·2
Instow	650	8	1·2
Ashford	151	2	1·3
Newton Tracey	140	2	1·4
Loxhore	192	3	1·5
Totals	7,565	83	Average 1·1
III. IMPERFECTLY SHELTERED PARISHES (12):			
Westleigh	483	2	
Fremington	1,188	10	
Atherington	475	5	
Bishop's Tawton	781	8	
Swimbridge	1,171	11	
Landkey	647	5	
Berrynarbor	652	2	·3
Martinhoe	165	1	·6
Coombe Martin	1,407	11	·7
Trentishoe	96	1	1·0
Countisbury	233	1	
Sherwell	370	1	
Totals	7,668	58	Average ·75

* See note, p. 4; also Chapter V.

TABLE V

Name of district.	Years of observation.	Sheltered parishes.	Exposed parishes.	Partly sheltered parishes.	Approximate ratio of death-rates in the exposed and sheltered parishes.
St. Thomas .	$2\frac{1}{3}$	·24	1·34	·57	5·5 to 1
Newton Abbot .	15	·83	1·38	1·08	3 to 2
Okehampton .	10	·61	1·72	1·28	3 to 1
Barnstaple .	10	·44	1·10	·75	2·5 to 1 (or 2 to 1 corrected; *see* note, p. 4)

there was so short, I felt justified, from a consideration of the figures furnished by the other Districts, in concluding that exposure to the west and south-west winds exercised a decided influence upon their phthisis mortality. This conclusion, with the arguments supporting it, formed the subject of a paper read before the Royal Medical and Chirurgical Society in October 1900.[1]

Objections

In the discussion which then took place the following objections were raised :

1. that the populations quoted were too small to found conclusions on ;

2. that the periods of observation were too short ;

3. that I had not carefully enough excluded the influence of racial differences ;

4. or of occupations ;

5. or of differences in closeness of intermarriage ;

6. or of differences in parish sanitation ;

7. that I should have confined my inquiry to female death-rates ;

8. that the wind had only exerted an indirect influence through the closure of windows and doors against it ;

and to these another objection has since been added, namely,

9. that the wind had only exerted an indirect influence through the damp which it drove into the walls.

[1] *Transactions*, vol. lxxxiv., p. 1.

REPLIES TO OBJECTIONS

To these objections I have replied as follows :

1. If it can be shown, in a *considerable number* of villages, in spite of the natural tendency of the small numbers of their populations to produce large exceptions to any law of incidence, that the law holds with no, or almost no, exceptions, then the most probable conclusion is, not that this absence of exception is itself a matter of chance, but that the law is so cogent that it overrides chance and compels conformity.

2. Ten years was the period chosen by Sir George Buchanan in his well-known report on phthisis and dampness of soil, as well as by Dr. Haviland in preparing his fine map of phthisis mortality in the Registration Districts of England and Wales. No objection that I have ever heard of has been made to their work on this score. Ten years seems at least a reasonable period.

3, 4, 5, 6. The Medical Officers of Health for the four Rural Districts assured me that in their Districts the objections relating to race, occupation, sanitation, and closeness of intermarriage could not be maintained.

7. The female death-rates bring out, as I shall presently show, even more strikingly than the death-rates of both sexes taken together, the influence of wind-exposure.

8. It is merely a matter of conjecture that doors and windows are especially closed in localities exposed to these winds. There is absolutely no evidence to prove it. The idea originated in the statement, by a distinguished medical authority, that he had noticed, whilst on a visit to the Scilly Islands, "that as a general rule doors and windows were closely shut, probably to keep out the winds," and this statement constitutes the entire literature of the subject! But cottage windows in the country districts of Devonshire—I cannot speak for the Scilly Islands—are generally shut in all weathers, and indeed many are not capable of being opened. Doors and windows, moreover, in Devonshire are not all on the west or south-west sides of the houses!

9. It is doubtful if a house exposed to rainy winds, on a hill-slope whence wet drains easily away, is as damp as one in a valley, on a clay soil which receives the drainage of the surrounding hills.

CHAPTER II

THE ELIMINATION OF CO-EXISTING INFLUENCES

THERE is thus, it will probably be admitted, a fair *prima-facie* case for the existence of this influence. But before proceeding with the proof it is necessary to define exactly the scope of the work, and to discover what other influences, if any, must be prevented from causing confusion.

SCOPE OF THE INQUIRY

The west and south-west winds, and to a less extent the north-west, are the prevalent strong rain-bearing winds of Devonshire. In dealing with rain-bearing winds in general therefore, only those which are strong and prevalent will be taken into account.

Further, it must be clearly understood that *what is here said has nothing to do with the effects of these winds on the course of existing cases* of phthisis. It is not necessarily true that influences which affect phthisis prevalence will correspondingly affect phthisis treatment. In many parts of the tropics, for instance, phthisis is decidedly infrequent, yet, so far from the climate being favourable to treatment, phthisis patients there do exceptionally badly. But it might be held as possible that an influence which produced an unusual prevalence of phthisis should be unfavourable to cases of the disease exposed to it; it ought to be remembered, however, that in many diseases certain modes of treatment may be sufficiently powerful to overcome environment. Malaria, for instance, may be successfully dealt with in regions where it is extremely prevalent; and recovery from phthisis is well known to occur occasionally in very unlikely places. At all events, the only safe course in the present work will be to keep the questions of influence on prevalence and influence on

course absolutely apart. Therefore, in the following chapters, only the influence on prevalence is under consideration.

Principle of Approximate Isolation of Influences

With regard to other influences which may either conflict with or intensify the influence of wind—and thus doubtless lead to serious confusion—some means must be found of eliminating them from the problem. There is a principle in climatology, to which I have drawn attention,[1] whose neglect is responsible for much of the uncertainty which surrounds that science. I have called it the principle of approximate isolation of influences. By such "approximate isolation" I mean, not the elimination of only one or two influences in the investigation of another influence, but the systematic enumeration of all the known—or supposed—influences which may affect the conditions investigated, the estimation of their actual effect, and their successive elimination, so far as that is possible. To this essential preliminary I propose to devote the present chapter.

The Enumeration of Other Influences

The influences, other than rain-bearing wind, known or supposed to affect the prevalence of phthisis are:

1. Race.
2. Closeness of intermarriage.
3. Sex.
4. Age.
5. Occupation.
6. Density of population.
7. Sanitation.
8. Poverty.
9. Prevalence of other tubercular diseases.
10. Soil.
11. Altitude.
12. Rainfall.
13. Preventive measures against the disease.
14. Atmospheric humidity.
15. Temperature.
16. Sunlight.
17. Dry winds.
18. Prevalence of other respiratory diseases.
19. Prevalence of malaria,

and to these must be added an important factor sometimes overlooked in comparative statistics, *viz.*:

[1] *Brit. Med. Journ.*, September 25, 1909.

20. Progressive change in prevalence with the lapse of time.

Their Actual Effects

I. RACE

Race has admittedly a very strong influence, and for the present purpose it does not matter whether this is exerted through inherited characters or racial habits. The negro suffers more than the white man when removed from his own country, although in it the disease is comparatively rare. In the West Indies the black troops have been shown to suffer more from phthisis than the British troops, and in the United States the negroes suffer more than the whites. The disparity between black and white also appears to increase with increasing distance from the Equator, as is seen in the two following tables.

TABLE VI

Comparative Table of Phthisis Death-rates amongst British and Negro Troops (From Hirsch)[1]

Station.	Deaths per 1,000.	
	British.	Negro.
Jamaica	6·2	7·5
Lesser Antilles	7·1	9·8
Mauritius	3·9	6·4
Bahamas	2·0	7·0
Gibraltar	6·1	33·5

TABLE VII

Comparative Table of Phthisis Death-rates (per 1,000 *Deaths from all Causes) in the White and Coloured Populations of the United States* (From Davidson)[2]

Region.	White.	Coloured.
Gulf Coast	115·8	120·6
South Mississippi River Belt	81·1	108·8
Central Region Plains and Prairies	136·8	221·4

[1] "Handbook of Historical and Geographical Pathology," vol. iii., p. 227.
"Geographical Pathology," vol. ii., p. 848.

According to Professor Osler[1] the North American Indians have an even higher death-rate from phthisis in the United States than the negroes, as shown by the Census for 1900, thus:

TABLE VIII

Comparative Phthisis Death-rates per 1,000 Deaths from all Causes

Whites	100·3
Negroes	165·5
North American Indians	222·3

The natives of British India, on the contrary, have collectively a lower liability to phthisis than the British—the native troops having only half the admission rate for phthisis of the British troops—but the different Indian races seem also to differ amongst themselves as regards proclivity to the disease. Thus, according to Dr. Alexander Crombie,[2] among 70,484 European troops in India the annual admission rate for phthisis, as stated in 1896, was 5 per 1,000 of strength, whereas amongst the native troops it was generally 2·5. The Rajputs and Sikhs appeared to be less liable to phthisis than the British, but the Dogras and Gurkhas more liable. In the Madras jails the Burmese convicts were thought to be specially prone to tuberculosis.

The Fiji Islands afford a good opportunity for a comparison of this sort. In a valuable and interesting letter, Dr. Glanvill Corney of Suva writes: "Natives of the New Hebrides and Solomon Islands, who are Negritos or Melanesians, appear to be more subject to tuberculosis in Fiji—to which country they emigrate as labourers—than the natives of Fiji are. So are natives of the Gilbert Islands, who also come to Fiji as immigrant labourers." Phthisis "is still very rare among Indian coolies in Fiji; but they are mostly selected men and women, medically examined with great care and precision."

Between white races also there are remarkable differences. According to the United States Census of 1900 the Irish in America have almost double the phthisis death-rate of the

[1] "The Principles and Practice of Medicine," 6th edition, p. 285

[2] "Report on the Recent Congress on Tuberculosis at Berlin, with special Reference to the Prevalence and Prevention of the Disease in India," by Alexander Crombie, M.D., Delegate for India, 1899.

Bohemians, whilst, on the other hand, the Jews have an exceptionally low phthisis death-rate.[1]

Obviously, therefore, decided racial difference must be carefully eliminated in any inquiry respecting phthisis prevalence, and the only way of doing this satisfactorily is to avoid comparisons between populations not practically uniformly of the same race.

2. CLOSENESS OF INTERMARRIAGE

Closeness of intermarriage has been ably urged by Dr. Charles Davies[2] as an important cause of the high death-rate from phthisis prevalent in the Isle of Man, and of the peculiar distribution of this death-rate among its parishes. It will be readily admitted, I think, by most people that, where a considerable proportion of a population is connected by marriage with a number of families of pronounced tubercular tendency, such consanguinity must tend to raise the general death-rate from phthisis. The arguments recently adduced against an inherited tendency to tuberculosis are not entirely convincing, and it will probably be admitted to be safer to abide, for the present purpose, by the older view. But, interesting as Dr. Davies's work is, he does not seem to me to have proved his point, for he has not conclusively shown that the degree of closeness of intermarriage in different districts definitely corresponds with the degree of phthisis prevalence. Also the effects of soil and wind have scarcely received the consideration they deserve; the parish of Lonan, for instance, on whose high death-rate much stress is laid by him, receives the drainage of a specially rainy area; and Haviland thought that wind-exposure played a part in determining the distribution of the phthisis mortality of the island. Further, the influence of occupation has been somewhat too summarily dismissed; Lonan contains a number of lead-mines, and lead-miners are notoriously prone to phthisis, which *in turn they can communicate to others*; lead-miners in England and Wales have thrice the phthisis mortality of fishermen, and four times that of farmers,[3] and fishing and farming are two other common occupations in the Isle of Man.

[1] Osler, *op. cit.*

[2] "The Causes of Consumption, with Special Reference to its Prevalence in the Isle of Man." 1899.

[3] Registrar-General's Reports.

Since phthisis is communicable, the fact that the women suffer slightly more than the men by no means disproves the influence of lead-mining. It may, on the other hand, be urged that the other lead-miners of the island—at the Foxdale mines—live in an area where the phthisis death-rate is considerably lower, the parish of St. Patrick ; but then the Foxdale mines lie in a very wind-sheltered valley, and under a lower rainfall.

So far as my inquiries in Devonshire have gone, I have been able to trace no influence of closeness of intermarriage on the prevalence of phthisis. Without venturing to suggest that such an influence does not exist, I consider it so slight that it may safely be neglected in the investigation of the influence of rain-bearing wind. At the same time, where possible, an endeavour will be made to inquire into it.

3. SEX

Sex derives importance chiefly from its relation to occupation. Female occupations are, on the whole, more uniform than male, and our country districts especially include few female occupations which create a special proneness to phthisis. In small areas also, like parishes, the women are more constantly at home than the men, whose employment may take them into neighbouring parishes for a considerable part of the day. It was reasonably objected to my first paper, the substance of which forms Chapter I, that it dealt with mixed male and female populations, and undoubtedly the restriction of as much of the later work as possible to female deaths has greatly tended to strengthen my conclusions. But it must at the same time be pointed out that, in the case of wind-exposure, the relation to phthisis prevalence comes out quite clearly in a study of mixed populations, although not so strikingly as when female deaths alone are made the basis of inquiry. When, therefore, mixed death-rates have to be considered, no fear need be felt that confusion will thereby be created.

4. AGE

Age has an influence, and so the age-constitution of a population might be thought to have some effect on the

TABLE IX

Female Phthisis Death-rates 1891–1900 (per 1,000 per annum)

In Standard Population.			Crude.
Worcestershire	·86	·84	Rutland
Middlesex	·88	·86	Worcestershire
Rutland	·89	·90	Middlesex
Westmoreland	·93	·92	Westmoreland
Surrey	·97	·95	Oxfordshire
Oxfordshire	·97	·95	Buckinghamshire
Leicestershire	·98	·96	Staffordshire
Berkshire	·99	·97	Leicestershire
Buckinghamshire	·99	·97	Wiltshire
Staffordshire	·99	·98	Berkshire
Wiltshire	1·01	·99	Essex
Somersetshire	1·03	1·00	Surrey
Essex	1·03	1·01	Somersetshire
Hertfordshire	1·06	1·01	Shropshire
Shropshire	1·06	1·01	Herefordshire
Herefordshire	1·06	1·03	Hertfordshire
Warwickshire	1·07	1·06	Warwickshire
Bedfordshire	1·08	1·06	Monmouthshire
Nottinghamshire	1·09	1·06	Huntingdonshire
Derbyshire	1·09	1·07	Nottinghamshire
Northamptonshire	1·10	1·07	Derbyshire
Sussex	1·10	1·07	Northamptonshire
Monmouthshire	1·10	1·18	Bedfordshire
Gloucestershire	1·12	1·12	Gloucestershire
Kent	1·13	1·12	Kent
Huntingdonshire	1·13	1·12	Dorsetshire
Dorsetshire	1·15	1·12	Norfolk
Cornwall	1·16	1·14	Sussex
Norfolk	1·17	1·15	Cornwall
Cheshire	1·18	1·16	Lincolnshire
East Riding	1·20	1·17	North Riding
Lincolnshire	1·21	1·19	East Riding
West Riding	1·21	1·19	Cambridgeshire
Cambridgeshire	1·22	1·20	Cheshire
North Riding	1·22	1·23	West Riding
Hampshire	1·23	1·23	Suffolk
Devonshire	1·28	1·25	Hampshire
Suffolk	1·29	1·27	Cumberland
London	1·29	1·29	Devonshire
Cumberland	1·32	1·35	London
Lancashire	1·34	1·36	Lancashire
Durham	1·46	1·42	Durham
Northumberland	1·57	1·56	Northumberland
South Wales	1·60	1·56	South Wales
North Wales	1·64	1·62	North Wales

prevalence of phthisis in it. Writers have attempted in two ways to minimise this possible source of error, *viz.*; (1) deaths only between certain ages—say the ages of 15 and 55—have been considered, as in Sir George Buchanan's work; or (2) the death-rate from the disease has been corrected to what it might be thought to be in terms of a standard population. The former method seriously reduces the numbers dealt with and, by excluding a number of undoubtedly phthisical deaths, tends rather to introduce error than to remove it. (It should be remembered in respect to this point that diagnosis at the present day is probably much more accurate than when Buchanan wrote, Koch's discovery of the tubercle bacillus having simplified our conception of the disease and furnished us with a specific test for it.) The second method therefore seems to be preferable; but here again the correction doubtless introduces slight errors of its own, whilst the accompanying table (Table IX) of comparison between the corrected and crude death-rates of the counties of England and Wales, 1891-1900, shows that the difference in the order of death-rate produced by the correction is far from great. Evidently the error due to varying age-constitution is not likely to embarrass the investigation of a strong climatic influence. Therefore, where correction for age-constitution cannot be made, no anxiety need be felt on the score of errors so caused.

5. OCCUPATION

Occupation has a very powerful influence on the phthisis-proclivity of the individual, as the following table (Table X) indicates.

But its influence on the general prevalence of phthisis in a considerable community, in which many occupations, good and bad, are mingled, is, as might be expected, far less pronounced. Thus, in Redruth District, in Cornwall, where tin-mining is very extensive, the death-rate in the decade 1881–1890 was 1·8 per 1,000, whilst in the Scilly Islands, where the people are chiefly fisher-folk, but are more exposed to south-westerly and westerly gales, the mortality during the same decade was 2·0 per 1,000. Staffordshire again, in spite of its potteries, has one of the lowest death-rates amongst

TABLE X

Showing the Comparative Mortality Figures of Males between 25 *and* 65 *Years Old in* 1890–91–92

Tin-miner	508	Engine-maker	195
Lead-miner	380	Woollen-maker	191
Potter	333	Hosiery-maker	190
Copper-miner	331	Shopkeeper	172
Brass-worker	279	Lace-maker	160
Stone quarrier	269	Shipwright	119
"General labourer"	253	Farm labourer	115
Zinc-worker	240	Fisherman	114
Carpet-maker	226	Coal-miner	97
Building trades	206	Ironstone-miner	90
Textile manufacturer	203	Artisan	88
Cotton-maker	202	Farmer	81

The above are selected from the "Supplement to the Fifty-fifth Annual Report of the Registrar-General in England," Part II., p. clxi.

the English counties. Even Leeds, Sheffield, Gateshead, and Newcastle-on-Tyne, populous, crowded, industrial, have lower phthisis death-rates than Anglesey and Holyhead, which have far less occupational cause for phthisis but are more exposed to westerly gales. In exceptional circumstances, where an occupation is almost universal amongst a population, the influence of that occupation on the general phthisis death-rate will doubtless be very great; but such circumstances are rare. To prevent error, such populations should be carefully excluded from consideration.

6. DENSITY OF POPULATION

There is no doubt that density of population has a powerful influence on phthisis prevalence, but there is also no doubt that exaggerated notions of its influence are widely prevalent. As a matter of fact, large town death-rates from phthisis are usually no more than 50 per cent. greater than country death-rates. In England and Wales, according to the Registrar-General's Report for 1907, the urban phthisis mortality is only 26 per cent. greater than the rural for males, whilst for females it is actually 5 per cent. less! In Scotland, in the Registrar-General's Report for 1900, the phthisis death-rates were as follows for town and country.

TABLE XI

	Rate per 1,000 per annum. Males.	Rate per 1,000 per annum. Females.
Principal Town Districts	1·98	1·79
Large Town Districts	1·71	1·68
Small Town Districts	1·53	1·41
Mainland Rural Districts	1·46	1·32
Insular Rural Districts	2·09	1·58

Here for males the death-rate in the largest towns is only about 30 per cent. greater than in the mainland rural districts, whilst it is actually a little less than in the insular rural districts. Females in the largest towns have a death-rate 35 per cent. greater than in the mainland rural districts, and only 13 per cent. greater than in the insular rural districts.

In Nottinghamshire, for the year 1903,[1] the rural phthisis mortality was greater than the urban, and in Norway, 1898 to 1900,[2] phthisis was also commoner in the rural than in the urban districts.

Where actual overcrowding exists, the influence of density of population becomes, as might be expected, more pronounced, although here, no doubt, the influence of "poverty" is superadded. In a valuable paper on the "Declension of Phthisis" Sir Hugh Beevor[3] has drawn attention to the extent of this influence in certain parishes of London. Where overcrowding affected under 12 per cent. of the population the phthisis death-rate had an average of 1·30 per 1,000, but where over 28 per cent. of the people were overcrowded it reached 2·44, or 88 per cent. more.

In regions where the country is open and exposed to strong, prevalent rainy winds we have an opportunity of seeing whether the influence of these winds may be stronger than the influence of density of population, since towns may be in a measure self-sheltering through the protection

[1] Report kindly sent me by the County Medical Officer of Health.
[2] Report kindly furnished me by Dr. Holmboë.
[3] *Lancet*, April 15, 1899.

afforded to the streets by their own buildings. Such regions are Western Prussia[1] and the Great Lakes Region of the United States.[2] In these regions phthisis mortality has been found to be heavier in the country districts than in the town districts (see Chapter VI).

It is evident, therefore, that even this influence of density of population is not strong enough to mask wholly the influence of strong rain-bearing winds. It clearly tends, however, to affect it considerably, so that it will be essential, where possible, to deal with town and country populations separately, and, where this is not possible, to expressly draw attention to the chance of fallacy thus introduced.

7. SANITATION

It might be supposed that those conditions which are included under the term of sanitation, apart from density of population (which indeed is difficult to separate from them), would considerably affect phthisis mortality, and it is surprising to find that, estimated in the only available way—in terms of general mortality, and especially after phthisis deaths have been subtracted from the deaths from all causes—sanitation has scarcely any, if any, influence on phthisis death-rate. Buchanan came to this conclusion from a comparison of typhoid death-rates and phthisis death-rates.[3] In examining the rural districts of Devonshire in 1900 the same want of correspondence became evident as shown in Table XII.

In examining the distribution of phthisis in the streets of Exeter no correspondence between general mortality and phthisis mortality could be discovered. Lastly, Sir Hugh Beevor's maps of phthisis distribution in England and Wales[4] and of the distribution of mortality from all causes (even without exclusion from this latter of deaths due to phthisis), indicate no correspondence between them, capable of causing confusion in considering such an influence as that now under discussion. Sanitation, therefore, apart

[1] Hirsch: "Handbook of Geographical and Historical Pathology," vol. iii., p. 179.

[2] Davidson: "Geographical Pathology," vol. ii., p. 848.

[3] Ninth Report of the Medical Officer of the Privy Council, 1866.

[4] *Op. cit.*

TABLE XII

Name of district.	Years of observation available.	Phthisis death-rate.	Death-rates from all causes except phthisis.
St. Thomas . . .	2	·89	12·84
Tiverton	6	1·05	13·45
South Molton . . .	8	1·28	13·51
Honiton	8	·93	13·59
Newton Abbot . .	8	·99	13·66
Bideford	7	·93	13·69
Totnes	7	1·07	13·84
Kingsbridge . . .	8	1·26	13·97
Great Torrington . .	8	·89	14·04
Barnstaple . . .	8	·83	14·05
Okehampton . . .	7	1·15	14·08
Crediton	8	1·35	14·23
Plympton . . .	8	1·23	14·49
Tavistock . . .	8	1·47	14·59
Axminster . . .	7	·67	14·63
Holsworthy . . .	8	1·08	14·68

from overcrowding, may be safely set aside where information regarding it is insufficient.

8. POVERTY

Poverty is difficult to separate from density of population. Phthisis may be rare where poverty is extreme, but at Budapest Körösi[1] calculates that there are 40 per cent. more deaths amongst the poor than amongst the rich. In dealing with phthisis in Exeter streets it will be seen that poverty (as estimated by rateable house-value) has a very considerable effect, but that that effect is not sufficient to interfere with the investigation of rain-bearing wind.

9. THE PREVALENCE OF OTHER FORMS OF TUBERCULOSIS

There is a curious want of correspondence often noticeable between the prevalence of phthisis and that of other forms of tubercular disease. Thus, in England and Wales the remarkable diminution in the phthisis death-rate which has occurred in the last half-century has not been accompanied by any considerable fall in the frequency of other tubercular diseases. Also although, roughly speaking, relatively high

[1] Bulstrode, "Milroy Lectures," *Lancet*, July 11, 1903, p. 78.

or low phthisis death-rate in the English counties is accompanied by relatively high or low death-rates from other forms of tubercle, there are considerable exceptions to this rule, as Table XIII shows. Again, in India, although phthisis amongst adults is not rare, other tubercular diseases amongst children are rare.[1] On the whole, it may be concluded that, in investigating the causes which greatly affect the prevalence of phthisis, it is not necessary to ascertain the prevalence of other forms of tubercular disease.

But there is another point of view from which to regard the prevalence of other tubercular diseases. In some districts, with which it will be necessary to deal, such as the Grisons, no separate returns are available for phthisis alone, all tubercular diseases being classed together; and the question arises whether it is permissible for us to draw conclusions relative to phthisis alone from such returns. To answer this question let us consider the effect of adding to the county phthisis death-rates of England and Wales the coincident death-rates for all other tubercular diseases (including "tabes mesenterica"). Table XIV gives the comparison.

From this it is obvious that, although the order of death-rate is considerably disturbed by the inclusion of deaths from other tubercular diseases, this disturbance by no means materially alters the broad distinction between counties of low and counties of high phthisis mortality. And it must be remembered that in England and Wales, owing to the recent fall in phthisis death-rate, the death-rate from other forms of tubercle is now proportionately higher as compared with the phthisis death-rate (and thus more likely to confuse the result) than in foreign countries where phthisis death-rate has not so declined. In England and Wales the female death-rates from phthisis and from other forms of tuberculosis (including "tabes mesenterica") between 1891 and 1900 were respectively 1·21 and ·56 per 1,000, the latter not far short of half of the former,[2] whereas in the Grisons, three-quarters of the tubercular cases were definitely stated to have been phthisis cases,[3] in the Report referred to.

I think therefore that it may be concluded that laws,

[1] Dr. Crombie's Report already referred to.
[2] Decennial Report of Registrar-General, issued 1907.
[3] Report issued by the Sanitary Department of the Grisons, 1895.

TABLE XIII

County.	Female phthisis death-rate per 1,000 per annum. 1891–1900	Female death-rates for other tubercular diseases (including "tabes mesenterica") per 1,000 per annum. 1891–1900
Rutland	·84	·47
Worcestershire	·86	·47
Middlesex	·90	·45
Westmoreland	·92	·57
Oxfordshire	·95	·41
Buckinghamshire	·95	·31
Staffordshire	·96	·55
Leicestershire	·97	·50
Wiltshire	·97	·39
Berkshire	·98	·37
Essex	·99	·52
Surrey	1·00	·38
Somersetshire	1·01	·38
Shropshire	1·01	·42
Herefordshire	1·01	·40
Hertfordshire	1·03	·37
Warwickshire	1·06	·49
Monmouthshire	1·06	·45
Huntingdonshire	1·06	·38
Nottinghamshire	1·07	·54
Derbyshire	1·07	·57
Northamptonshire	1·07	·44
Bedfordshire	1·08	·46
Gloucestershire	1·12	·44
Kent	1·12	·51
Dorsetshire	1·12	·37
Norfolk	1·12	·40
Sussex	1·14	·47
Cornwall	1·15	·45
Lincolnshire	1·16	·50
North Riding	1·16	·50
East Riding	1·17	·64
Cambridgeshire	1·19	·41
Cheshire	1·20	·57
West Riding	1·23	·60
Suffolk	1·23	·45
Hampshire	1·25	·49
Cumberland	1·27	·52
Devonshire	1·29	·49
London	1·35	·65
Lancashire	1·36	·64
Durham	1·42	·87
Northumberland	1·56	·62
South Wales	1·56	·55
North Wales	1·62	·52

plainly indicated by the distribution of tubercular diseases in regions like the Grisons, where phthisis is so much commoner than other forms, may be reasonably held to apply to phthisis specially as well as to tubercle generally.

TABLE XIV

Crude Female Death-rates per 1,000 *per Annum*, 1891–1900, *Arranged in Regular Ascending Order*

Phthisis.		All Tubercular Diseases.	
Rutland	·84	1·26	Buckinghamshire
Worcestershire	·86	1·31	Rutland
Middlesex	·90	1·33	Worcestershire
Westmoreland	·92	1·35	Middlesex
Oxfordshire	·95	1·35	Berkshire
Buckinghamshire	·95	1·36	Oxfordshire
Staffordshire	·96	1·36	Wiltshire
Leicestershire	·97	1·38	Surrey
Wiltshire	·97	1·39	Somersetshire
Berkshire	·98	1·40	Hertfordshire
Essex	·99	1·41	Herefordshire
Surrey	1·00	1·43	Shropshire
Somersetshire	1·01	1·44	Huntingdonshire
Shropshire	1·01	1·47	Leicestershire
Herefordshire	1·01	1·49	Westmoreland
Hertfordshire	1·03	1·49	Dorsetshire
Warwickshire	1·06	1·51	Staffordshire
Monmouthshire	1·06	1·51	Essex
Huntingdonshire	1·06	1·51	Monmouthshire
Nottinghamshire	1·07	1·51	Northamptonshire
Northamptonshire	1·07	1·52	Norfolk
Derbyshire	1·07	1·55	Warwickshire
Bedfordshire	1·08	1·54	Bedfordshire
Gloucestershire	1·12	1·56	Gloucestershire
Kent	1·12	1·60	Cornwall
Dorsetshire	1·12	1·60	Cambridgeshire
Norfolk	1·12	1·61	Nottinghamshire
Sussex	1·14	1·61	Sussex
Cornwall	1·15	1·63	Derbyshire
Lincolnshire	1·16	1·63	Kent
North Riding	1·17	1·66	Lincolnshire
Cambridgeshire	1·19	1·68	Suffolk
East Riding	1·19	1·73	Hampshire
Cheshire	1·20	1·74	East Riding
Suffolk	1·23	1·77	Cheshire
West Riding	1·23	1·78	Devonshire
Hampshire	1·25	1·79	Cumberland
Cumberland	1·27	1·81	North Riding
Devonshire	1·29	1·83	West Riding
London	1·35	1·90	Lancashire
Lancashire	1·36	2·00	London
Durham	1·42	2·11	South Wales
Northumberland	1·56	2·14	North Wales
South Wales	1·56	2·29	Durham
North Wales	1·62	2·38	Northumberland

10. SOIL

The influence of soil is definitely less powerful than that of wind-exposure.

TABLE XV

Registration Districts in the Order of their Proper Mortality from Consumption (Buchanan)

Name of district.	Mean phthisis death-rate of two sexes, 15—55.	Shelter and exposure as regards S.W. Wind.*
Dartford	261	S
Epsom	277	—
Milton	276	S
Godstone	282	—
North Aylesford	289	S
Dover	296	S
Bromley	294	—
Steyning	295	s
Chertsey	296	S
Croydon	303	—
Cranbrook	311	—
Richmond	313	—
Kingston	315	—
Elham (*a*)	277	—
Blean	315	S
Bridge (*b*)	331	—
Gravesend (*c*)	405	S
East Grinstead	333	—
Reigate	337	—
Eastbourne (*d*)	336	S
Farnham (*e*)	292	—
Hambledon	343	—
Battle (*f*)	294	—
Canterbury (*g*)	384	—
Hollingbourne	352	—
Malling	356	—
East Ashford	359	x
Sevenoaks	361	—
Guildford	369	—
Farnborough (*h*)	291	—
Eastry	371	S
Faversham	370	S
Rye	371	—
Maidstone (*i*)	434	—
Cuckfield	387	x
Dorking	399	—
Uckfield	398	—
Hailsham	392	x
Ticehurst	401	—
Worthing (*j*)	419	X
West Ashford	421	x
Lewes (*k*)	502	x
Tenterden	435	—
Horsham	440	X
Westhampnett (*l*)	441	X
Midhurst	455	—
Thakeham	454	x
Petworth	462	—
Westbourne	498	X
Chichester (*m*)	566	X

TABLE XV (*continued*)

Eight Districts whose Order is Uncertain amongst the Others

Name of district.	Mean phthisis death-rate of two sexes, 15—55.	Shelter and exposure as regards S.W. wind.*
Sheppey	202	S
Hastings	498	X
Thanet	392	s
Hoo	301	S
Tunbridge	399	—
Medway	480	—
Romney Marsh . . .	348	? s
Brighton	435	X

* S = well sheltered; s = fairly sheltered; X = fully exposed; x = fairly exposed. Doubtful districts are unmarked.

Sir George Buchanan's Notes.—(*a*) Of Elham, the male rate being of no value, ten has been subtracted from the female rate for the approximate true mean 313. (*b*) The rates of Bridge become 342 mean and 425 female if corrected for Canterbury Hospital. (*c*) Gravesend has been classed by its female rate as being more trustworthy than the mean. (*d*) The rates of Eastbourne might, perhaps, be taken as slightly smaller in consideration of some invalid visitors. (*e*) Registered male rate of Farnham being of no value, ten has been subtracted from the female rate for the approximate true mean 339. (*f*) At Battle correction for obvious inclusion of much phthisis in registered lung disease brings phthisis rate to 344 mean and 398 female. (*g*) For Canterbury deduction for hospital patients brought from other districts makes true mean rate 348 and female rate 298. (*h*) For Farnborough, the registered male rate being of no value, ten has been subtracted from the female rate for the approximative true mean 371. (*i*) In Maidstone deduction for deaths in lunatic asylum patients brought from other districts makes true mean rate 379 and true female rate 405. (*j*) At Worthing the rate should, perhaps, be taken as somewhat smaller in consideration of some invalid visitors. (*k*) In Lewes correction for hospital and prison brings the true rate to 426 mean and 464 female. (*l*) The rates of Westhampnett become 449 mean and 521 female if corrected for Chichester Hospital. (*m*) At Chichester deduction for hospital deaths in patients from other districts brings the rates to 536 mean and 450 female rate.

If Sir George Buchanan's figures[1] be examined it will be found that, although the area he reported on was well adapted to show the effect of soil and ill adapted to show the influence of rainy wind, yet his tables better illustrate the influence of the wind than the influence of the soil. The south-west wind is the prevalent wind in that area, and it is a rainy wind. If Buchanan's districts are arranged in his own order of ascending phthisis death-rate (see Table XV), it will be found that the districts obviously much sheltered

[1] Tenth Report of the Medical Officer of the Privy Council, 1867.

from south-west wind come at the beginning of the table and those obviously much exposed to it at the end. Again, if Buchanan's two tables of "fairly comparable districts" are taken (only excluding from them the districts which he himself considered doubtful and the districts which are obviously much exposed to south-west wind) (Tables XVI and XVII), and if in each table a comparison be made between the average phthisis death-rate of the districts in

TABLE XVI

Districts the Majority of whose Population Live on the Weald Country (omitting Hastings and Tunbridge, which were doubtful, and Horsham, Hailsham, and Cuckfield, which are Exposed to South-west Wind)

Name of district.	Percentage of population on wetter soils.	Phthisis death-rate per 100,000.
Cranbrook . . .	18	311
East Grinstead . .	18	333
Uckfield . . .	17	398
Battle	20	344
Rye	21	371
Maidstone . . .	24	379
Averages . .	19·6 per cent.	356
Hambledon . . .	41	343
Ticehurst . . .	33	401
Tenterden . . .	58	435
Petworth . . .	70	462
Averages . .	50·0 per cent.	410

Here an increase of 155 per cent. in the proportion of the population living on the wetter soils only entails an increase of 15 per cent. in the phthisis death-rate.

which less than 30 per cent. of the inhabitants live on wetter soils and the death-rate of the districts in which more than 30 per cent. of the inhabitants do so, it will be found that dampness of soil produced less effect on phthisis mortality than did exposure to south-west wind as illustrated in Table XVIII.

In St. Thomas Rural District I have mentioned the fact that, until the influence of wind was eliminated by only comparing sheltered parishes with sheltered, and exposed

TABLE XVII

Districts where Half or More of the People Live on Lower Greensand (omitting West Ashford and Thakeham, which are Exposed to South-west Wind)

Name of district.	Percentage of population on wetter soils.	Phthisis death-rate per 100,000.
Godstone	13	282
Elham	24	313
Reigate	27	337
Malling	20	356
Averages	21 per cent.	322
Hambledon	41	343
Sevenoaks	40	361
Dorking	32	399
Midhurst	58	455
Averages	42 per cent.	389

Here an increase of 100 per cent. in the proportion of the population living on the wetter soils only entails an increase of 20 per cent. in the phthisis death-rate.

TABLE XVIII

Very Sheltered and Very Exposed Districts as regards South-west Winds.

Very Sheltered Districts.		Very Exposed Districts.	
Name of district.	Phthisis death-rate.	Name of district.	Phthisis death-rate.
Milton	276	Chichester	536
Dover	296	Worthing	419
Eastbourne	336	Westhampnett	449
Dartford	261	Horsham	440
Faversham	370	Westbourne	498
Gravesend	331		
North Aylesford	289		
Chertsey	296		
Eastry	371		
Average	314	Average	468

Here the differences in the death-rate are much more obvious and uniform and the average of the exposed districts is 49 per cent., of itself higher than that of the sheltered.

with exposed, the influence of soil could not be demonstrated. Similarly in Exeter streets the influence of soil has been shown by me to be unrecognisable, until only those streets

were considered whose roadways are sheltered from south-west, west, and north-west winds, when it became easily recognisable—indeed, I think, unmistakable (see Chapter IV).

It is, in fact, owing to this relative feebleness of the influence of soil as compared with that of wind that Sir George Buchanan's views have been so long and so successfully opposed, for the objections to his conclusions had never been replied to, until the conflicting and overmastering influence of wind-exposure was shown to be interfering with the effects of soil.[1]

Whilst, therefore, it is desirable, as far as possible, to compare districts of similar soil in discussing the effect of wind, it is fortunate, since that is practically impossible on an extensive scale, that the effect of soil is so much weaker than that of wind as not to vitiate the results when soil is left out of account.

II. ALTITUDE

The influence of altitude, if indeed it should be proved to exist, is certainly far too slight to interfere with the investigation of the influence of wind.

It does not concern us here to demonstrate the weaknesses of the evidence in favour of the theory that increasing altitude *per se* tends to diminish the prevalence of phthisis. But the following indicates at least the slightness of its influence.

The latest figures prepared to show the influence of altitude with which I am acquainted were published in 1895 by the Cantonal Government of the Grisons. This canton affords an excellent field for comparing death-rates both at different altitudes and under different conditions of wind-exposure and shelter. The Report dealt not with death-rate, but with morbidity, *i.e.* with the number of living cases in the community. The morbidity-rates are probably treble the annual death-rates.[2]

The rainy winds of Central Europe are the south-west, west, and north-west, together with, to a less extent, the

[1] "The Influence of Soil on Phthisis as Illustrating a Neglected Principle in Climatology." *Brit. Med. Journ.*, September 25, 1909.

[2] Huggard: "A Handbook of Climatic Treatment," p. 124. London, 1906.

south-east and south. Of these, the west wind can only reach the Grisons much broken and dried from its transit over the Alps; the south-west, as a rainy wind, only considerably affects the Upper Engadine; the south-east has probably some effect as a rainy wind on the highest villages of the valleys which run down into Italy; only the north-west, with the north-north-west and west-north-west, entering at the gap of the Rhine Valley, can widely affect the canton. These north-westerly winds are especially prevalent in the summer months, the time of the principal rainfall of this region.[1]

The table published by the Cantonal Government was

TABLE XIX

Tuberculosis in the Grisons. Being a Summary of Tables published by the Cantonal Government in 1895, *rearranged for Equal Intervals of Height*

	Tuberculosis Morbidity per 1,000.
(*a*) Places up to 600 metres high	12·08
(*b*) Places from 601 to 800 metres high	8·8
(*c*) ,, ,, 801 ,, 1,000 ,, ,,	12·5
(*d*) ,, ,, 1,001 ,, 1,200 ,, ,,	7·1
(*e*) ,, ,, 1,201 ,, 1,400 ,, ,,	7·5
(*f*) ,, ,, 1,401 ,, 1,600 ,, ,,	4·2
(*g*) ,, ,, 1,601 ,, 1,880 ,, ,,	8·6

arranged in unequal divisions of altitude, and it was first necessary to rearrange it in equal divisions. I chose 200-metre intervals. So arranged (Table XIX), it by no means made clear a definite effect of altitude, and at each height pronounced exceptions occurred, which suggested some more potent influence at work. It seemed possible that this was rainy wind. Accordingly, a table (Table XX) was constructed, showing the tuberculosis morbidity-rates in localities exposed to various winds; from this it became at once obvious that a higher rate of morbidity accompanied exposure to winds from any westerly quarter. Next a table (Table XXI) was drawn up of localities with rates under 5 per 1,000 and of localities with rates over 10 per 1,000. The places with the lower morbidities were then, with few exceptions, seen to be sheltered from all westerly winds, whilst the places with the higher morbidities were, with few

[1] Hann: "Handbuch der Klimatologie."

TABLE XX

Tuberculosis in the Grisons. Summary as regards Shelter and Exposure

Shelter and exposure.	Population.	Tuberculosis Morbidity per 1,000
Sheltered from all	18,734	5·3
Exposed only to W.N.W., N.W., or N.N.W.	9,256	13·2
,, ,, N. or N.E.	6,043	6·9
,, ,, E.N.E., E., or S.E.	6,173	5·8
,, ,, W.	280	14·2
,, ,, S.W. or W.S.W.	118	19·7

It should be observed that the populations exposed to W., S.W., and W.S.W., are very much smaller than the others.

TABLE XXI

Low Morbidities (under 5·0 *per* 1,000)

San Vittore	3·87	Sheltered.
Roveredo	1·87	,,
Lostallo	2·81	,,
Mastrils	2·64	S.E., E.
Maladers	4·17	Sheltered.
Brusio	0·87	,,
Scharans	4·07	N.W.
Tomils	3·58	Sheltered.
Stampa	1·86	,,
Luvis	3·70	Broken W.S.W. and E.N.E.
Somvix	1·71	E.N.E.
Filisur	3·66	Sheltered.
Flims	3·79	,,
Disentis	0·75	,,
Cumbels	3·02	N.E.
Praz	4·31	,,
Klosters	1·31	Sheltered.
Churwalden	4·41	N.
Remüs	1·88	Sheltered.
Villa	3·75	N.E.
Schuls	3·17	Sheltered.
Vals	2·82	N., N.N.E..
Brigels	1·18	Sheltered.
Lumbrein	3·74	N.E.
Tarasp	3·11	Sheltered.
Lavin	4·08	,,
Schleins	4·78	,,
Safien	1·90	N.N.E.
Davos	2·06	S.W., N.E.
Ponte	4·74	Sheltered.
Zuoz	4·66	,,
Celerina	3·38	,,
Pontresina	3·92	,,

Of these, Scharans may be regarded as perhaps a fairly exposed place to N.W. Its population is 492. Davos seems to have a dry S.W. wind.

TABLE XXI (*continued*)

High Morbidities (*over* 10·0 *per* 1,000)

Maienfeld	12·22	W.N.W.
Haldenstein	19·14	N.E.
Igis	17·03	N.W.
Zizers	13·16	,,
Chur	15·44	W.S.W., N.
Rothenbrunnen	37·50	(?)
Jenins	11·99	W.N.W.
Bonaduz	13·27	(?)
Fürstenau	12·66	N.W. (?)
Schiers	11·04	Sheltered (?).
Tamins	11·97	W.S.W., E.N.E.
Sils	15·87	N.W.
Ilanz	10·17	W., E.
Thusis	11·23	N.N.W., deflected.
Küblis	19·53	Sheltered (?).
Vallendas	19·44	W.S.W., E.N.E.
Tiefenkastel	25·13	N.W.
Arvigo	12·90	Sheltered.
Trins	18·06	W.S.W.
Surava	14·60	W.
Fürth	18·02	N.E.
Versam	10·26	W. and E.
Fanas	10·79	(?) W.S.W.
Andeer	10·43	N.
Saas	10·65	(?) Sheltered.
Alvaschein	13·89	N.W.
S. Domenica	10·64	Sheltered.
Pitasch	25·86	N.W.
Valzeina	23·26	N. (?) N.W.
Brienz	26·32	W.
Andest	17·94	(?).
Portein	21·28	Sheltered (?).
Duvin	17·70	N.N.W.
Conters	44·87	N.W.
Obervatz	13·02	S.W.
Sarn	16·76	N.E.
Landavenca	17·24	Sheltered.
Salux	12·90	N.W.
Roffna	25·00	,,
Tinzen	16·06	,,
Lenz	31·43	S.W.
Bergün	11·71	N.W.
Langwies	13·11	Sheltered (?).
Stürvis	11·24	N.W.
Wiesen	12·05	(?) S.W.
Feldis	20·13	N.W.
Innerferrara	13·87	N.N.W.
Parpan	14·71	N.W.
Sur	21·90	Sheltered (?).
Fetan	13·82	,,
Guarda	11·45	Sheltered.
Sils	30·93	S.W., N.E.
Arosà	22·73	S.W., S.E.

Of these, Haldenstein may get deflected westerly winds. Its inhabitants and those of Sur can scarcely go any distance out of doors without encountering north-west wind. Fetan lies so high it probably gets some S.W. down the valley.

certain exceptions, exposed to south-west, west, or north-west winds. Again, as the winds causing the higher morbidity-rates were usually north-westerly, another table (Table XXII) was constructed, comparing at each altitude the morbidity-rates in the populations sheltered from west-north-west, north-west, and north-north-west winds, with the rates in the populations exposed to these winds. This result was very striking. At each level the exposed population suffered far more (twice to seven times as much) from tuberculosis than the sheltered population.

TABLE XXII

The N.W., N.N.W., and W.N.W. Winds. Effect of Exposure to, and Shelter from, them at various Heights (Summary). It should be observed that the exposed populations at 801–1,000, *at* 1,001–1,200, *and at* 1,401–1,600 *metres, are very small.*

Altitude in metres.	Fully Exposed to N.W.		Fully Sheltered from N.W.	
	Population.	Morbidity per 1,000.	Population	Morbidity per 1,000.
Up to 600 . .	14,039	14·4	4,874	5·3
601 ,, 800 . . .	1,937	12·4	4,004	5·2
801 ,, 1,000 . . .	199	25·1	2,369	6·3
1,001 ,, 1,200 . . .	260	19·2	7,212	5·6
1,201 ,, 1,400 . . .	2,092	15·3	5,237	2·4
1,401 ,, 1,600 . . .	270	18·5	8,273	3·8
1,601 ,, 1,880 . . .	0	—	4,966	8·8

These tables suffice to indicate all that here concerns us, *viz.* that the influence of altitude (if any) does not interfere with the investigation of the influence of wind-exposure, and that, therefore, altitude may without danger be neglected.

In Devonshire the only effect of altitude I can discover is that it tends to increase the effects of exposure in exposed places.

12. RAINFALL

Rainfall *per se* seems to have little, if any, effect. At Quito the rainfall is 70 inches, and at Lagos it is 56, phthisis being rare in both places, and such examples might be multiplied without difficulty. The rainfall map of the United States by no means corresponds with a map of its phthisis distribution.

On the other hand, a very low rainfall within the Tropics may co-exist with much phthisis, as along the coast of Peru.[1]

In Grasmere,[2] with a rainfall of 88 inches, the female death-rate for phthisis over a period of thirteen years has only been ·6 per 1,000. In twenty-three parishes of North Devon rainfall will be seen to make little, if any, difference *from place to place* (Chapter V).

Taken, however, in conjunction with wind-exposure, or with soil, rainfall may have a very decided influence. This is shown by the charts given in Chapter V, where the amount of rainfall *from year to year* had apparently a remarkable effect. That, however, as will be seen, in no way interfered with the investigation of the effect of rain-bearing winds.

13. PREVENTIVE MEASURES AGAINST THE DISEASE

How far such measures really modify the prevalence of phthisis remains to be seen. It is only reasonable to expect that they may do so considerably. Where preventive measures are now active, therefore, it will be wiser to consider the older death-rates before these measures were introduced. In Germany, partly for this reason, I have preferred the older figures of Schlockow to newer statistics, which may be affected by the important steps taken in that country to lessen the incidence of the disease.

14. ATMOSPHERIC HUMIDITY

There is at present no means of estimating this on an extensive scale. It no doubt forms part of the influences of rain-bearing winds and dampness of soil, and therefore can scarcely be held to interfere practically with their consideration.

15. TEMPERATURE

Temperature alone seems to have little, if any, effect. Thus, in cold climates phthisis may be rare, as in Iceland, or common, as in West Greenland,[3] and in hot climates rare, as

[1] Davidson, *op. cit.*, vol. ii., p. 970.

[2] Private letter from Dr. B. R. Johnston.

[3] Clemow: "The Geography of Disease," p. 461. Cambridge, 1903.

in Upper Egypt, or prevalent, as in Tahiti.[1] In climates of small mean annual range of temperature it may be rare, as at Lagos, or common, as at Georgetown in British Guiana; and where the mean annual range is great, rare or absent, as in the Khirghiz Steppes, or frequent, as in Mid-Russia. Even mean daily range seems to make no definite difference; phthisis is rare at Luxor and common at Moscow, both of which have a great daily range.

16. DRY WINDS

Dry winds seem to have little effect as compared with rainy winds. The plains of Colorado, South Africa, and inland Australia furnish ample evidence that strong dry winds, even when sometimes laden with dust, can co-exist with low phthisis mortality. That they have some effect seems, however, probable. Thus, in Northern Nigeria, where the disease is rare, the cases which do occur present themselves after cold dry winds have been blowing.[2]

In Chapter III it will be seen that winds from easterly directions—*i.e.* relatively dry winds in Devonshire—did not interfere with the demonstration of the influence of the rain-bearing winds from westerly directions.

17. SUNLIGHT

That abundant, intense sunlight may affect the prevalence of phthisis seems not improbable, since it has so deadly an effect on living tubercle bacilli exposed to it. Unfortunately, we have no information. Perhaps the relative rarity of phthisis in many tropical countries, in spite of their warmth and moisture, may be due to an action of light on the bacilli in the expectoration. The contrast, also, in tropical countries, between rarity of origin and perniciousness of type may have some such explanation. In the method adopted in dealing with foreign countries in Chapter VI, of comparing death-rates, it will be seen that there is little scope for error from this source, since, within the areas of comparison, extreme differences in the amount of sunshine do not usually exist.

[1] Davidson, *op. cit.*, vol. ii., p. 77.
[2] Letter from a friend in practice there.

18. PREVALENCE OF OTHER "RESPIRATORY DISEASES"

Other "respiratory diseases" appear not to affect the prevalence of phthisis, but to follow quite different laws. In the United States, for instance, the distribution of pneumonia is almost the converse of that of phthisis (See Maps 20 and 21), and whilst phthisis is commoner there than in England, bronchitis appears to be rarer.[1] As the curious contrast between the distribution of pneumonia and that of phthisis is noticeable in several countries, it has seemed worth while to add the maps which illustrate it in the United States.

19. PREVALENCE OF MALARIA

There is no evidence that malaria-prevalence affects phthisis-prevalence to any considerable degree, if at all. This, I believe, is now generally agreed. Both diseases may be prevalent in the same place, as in Austria, Italy, Japan, and the coast of Brazil.

20. PROGRESSIVE CHANGE OF PREVALENCE WITH THE LAPSE OF TIME

In England and Wales phthisis has steadily declined for more than fifty years. In Norway and Ireland it is at present increasing. It is needless to multiply instances, but it is obviously highly important to compare only contemporary records in dealing with phthisis death-rates.

Their Elimination

The precautions necessary on account of these other influences may therefore be summed up as follows:

Race.—Only populations of the same race should be compared with each other.

Sex.—Where possible, only female death-rates should be used.

Occupation.—Localities where a special industry is almost universal should be excluded from consideration.

[1] Davidson, *op. cit.*

Density of Population.—Town and country should not be compared with each other.

Preventive Measures.—Figures referring to periods previous to the introduction of these may perhaps be preferable.

Date.—Only contemporary records should be compared.

The remaining influences, *viz.* closeness of intermarriage, age-distribution, sanitation, poverty, prevalence of other tubercular diseases, soil, altitude, rainfall, atmospheric humidity, temperature, dry winds, and sunlight (where they cannot be investigated) may be safely regarded as at least most unlikely to introduce error. This statement, justified by the foregoing, will, I think, be further justified by the contents of the succeeding chapters.

CHAPTER III

THE INFLUENCE OF PREVALENT STRONG RAIN-BEARING WINDS ON THE FEMALE PHTHISIS MORTALITY IN OKEHAMPTON RURAL DISTRICT DURING THE TEN YEARS 1890–1899

THE Rural District of Okehampton occupies the centre of the south-western peninsula of England,[1] and all the winds which reach it from due west, south-west, south-east, east, north, and north-west, reach it from the sea over about an equal breadth of land. The north-east, which has to travel to it across England, is the only really "land" wind. The south is the one wind which practically does not reach it at all, being cut off by the whole width of the tableland of Dartmoor.

As regards exposure, the district is about the most generally exposed in Devonshire. Raised at its southern extremity on the north escarpment of the moor, it spreads northwards over its northern spurs and the sheltered valleys they enclose, thus presenting to almost all winds except the south a number of marked contrasts between shelter and exposure.

The geological formation is comparatively simple (Map 12, Plate IV). Almost the whole District consists of carbonaceous shale, the only other formations present being a narrow strip of red sandstone running in at the north-east, the Dartmoor granite occupying part of the south and south-east, and a very small patch of alluvium in the north, on which last there are no dwellings.

The rainfall unfortunately cannot be stated as accurately as one could wish, owing to the paucity of observations; but from a general survey of the rainfall of the county (Map 3, Plate I) it may perhaps be deduced with a tolerable degree of certainty. It is probably fairly uniform across the District from west to east; and is heavier in the south than in the

[1] See Map 1.

TABLE XXII

Okehampton Rural District. (Dr. Young's figures.) Phthisis Deaths amongst Females in Ten Years, 1890–1899

	Female population, 1891.	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	Total female deaths, 1890–1899.	Rate per 1,000 per annum.
North Tawton	927	4	2	2	1	1	..	1	1	..	..	12	1·3
Sampford Courtenay	429	3	..	3	2	..	..	3	..	..	..	11	2·5
Bondleigh	67	..	..	..	..	..	..	..	..	..	..	0	0
Bratton Clovelly	255	2	3	..	..	1	1	..	..	1	..	8	3·1
North Lew	364	..	1	1	2	1	2	..	..	1	2	10	2·7
Beaworthy	122	1	1	..	1	..	..	..	..	..	..	3	2·4
Highampton	135	..	..	2	..	..	..	..	1	2	..	5	3·7
Jacobstowe	113	..	..	1	..	..	1	..	..	..	..	2	1·7
Hatherleigh	724	..	..	..	2	1	1	1	..	1	..	6	·8
Inwardleigh	258	1	..	..	..	..	..	..	..	..	..	1	·4
Iddesleigh	197	2	..	..	..	..	..	..	..	1	..	3	1·5
Chagford	728	1	1	..	1	3	..	..	1	..	..	7	·9
Throwleigh	149	1	..	..	..	..	..	1	..	..	..	2	1·3
Sourton	217	2	1	..	3	..	1	..	..	..	1	8	3·6
South Tawton	633	..	2	..	..	..	..	2	2	1	2	9	1·4
Bridestowe	309	1	..	2	..	..	..	..	..	..	2	5	1·6
Drewsteignton	378	..	1	..	1	..	1	..	..	..	..	3	·8
Germansweek	102	..	1	..	1	..	..	..	1	..	1	4	3·9
Broadwood Kelly	132	..	1	..	..	..	..	..	..	..	..	1	·7
Exbourne	167	..	..	1	..	1	..	..	..	..	2	4	2·4
Belstone	89	..	..	..	..	..	..	..	..	1	..	1	1·1
Spreyton	193	..	..	..	..	1	1	..	..	1	..	3	1·5
Meeth	91	..	..	..	..	..	..	..	1	..	..	1	1·1
Ashbury	37	..	..	..	..	..	..	..	..	..	..	0	0
Gidleigh	57	..	..	..	..	..	..	..	..	..	..	0	0
Honeychurch	17	..	..	..	..	..	..	..	..	..	..	0	0
Monkokehampton	83	..	..	..	..	..	..	..	..	..	..	0	0
Okehampton (rural) about	300	..	1	..	..	2	..	1	..	..	..	4	about 1·3
Total Female Population	7,273							Total Female Deaths				113	

TABLE XXIII

Descriptions of 103 *of the Cases considered (remainder unknown)*

	Cases		Cases
Daughter of farmer	19	Brought forward	87
Wife or widow of farmer	16	Wife of coal agent	1
Daughter of labourer	13	,, thatcher	1
Domestic servant	10	,, porter	1
Wife or widow of labourer	9	,, miller	1
Wife of tailor	3	,, bootmaker	1
Worker in wool factory	3	,, dentist	1
Wife of gardener	2	,, grocer	1
Daughter of blacksmith	2	,, baker	1
Daughter of farm bailiff	2	Daughter of wheelwright	1
Dressmaker	2	,, yeoman	1
Housekeeper	2	,, butler	1
Wife of sergeant	1	,, tailor	1
,, corn merchant	1	,, stone cutter	1
,, draper	1	,, bootmaker	1
,, station-master	1	Foremaid in shop	1
Carried forward	87	Drapers' assistant	1
		Total	103

north, being about 50 inches at Okehampton and about 40 inches at Hatherleigh.

The female population may be said to be free from specially "occupational" phthisis, as will be seen from Table XXIII. A woollen factory at North Tawton occupies many men, women, and children, but evidently does not exercise any important influence on the phthisis mortality in its neighbourhood.

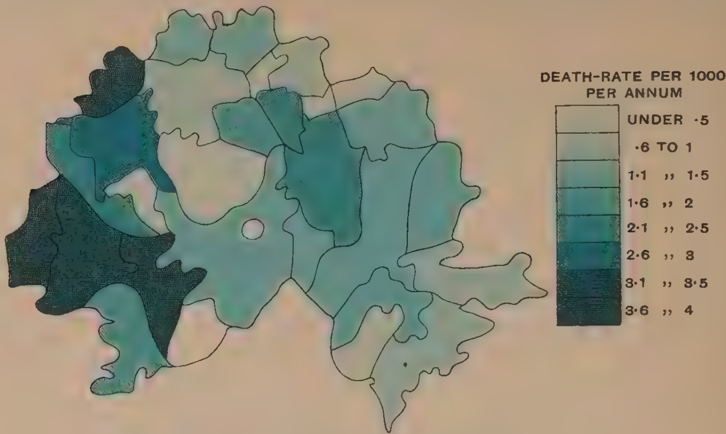
The Medical Officer of Health for Okehampton, Dr. Young, has informed me that no racial differences exist in the District, unless Mr. Baring Gould is correct in supposing that the inhabitants of Germansweek are different from the rest. If it be so, the difference is not discoverable from its phthisis death-rate, which corresponds with those of its neighbours. It is true it is a little higher, but then it is especially wind-swept.

Dr. Young says that intermarriage is not closer in any one of his parishes than in another, with the exception of Beaworthy, where the people intermarry more closely than elsewhere. It will be seen that this produces no noticeable effect. Dr. Young also considers that village and town sanitation is practically uniform all over the district.

I have confined my observation to phthisis deaths amongst

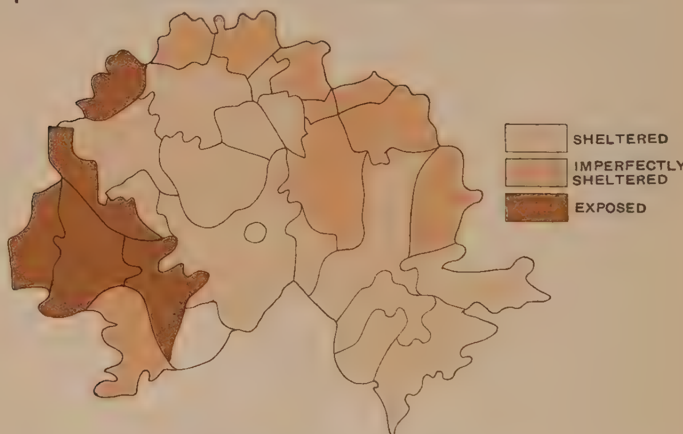
OKEHAMPTON RURAL DISTRICT
Phthisis Death-rates among Females in the Parishes between 1890 and 1899

Map 4



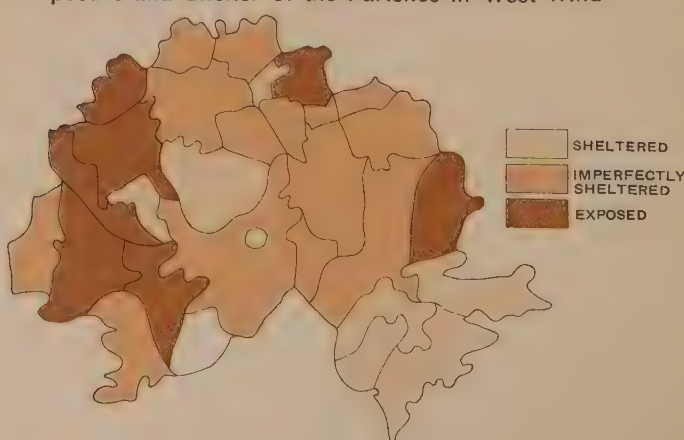
OKEHAMPTON RURAL DISTRICT
Exposure and Shelter of the Parishes in South-west Wind

Map 5



OKEHAMPTON RURAL DISTRICT
Exposure and Shelter of the Parishes in West Wind

Map 6



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females. Thanks to Dr. Young, who most kindly, and with great care, supplied me with the requisite information, I have been able to consider those deaths in the separate parishes over the ten years, 1890–1899. He also verified for me my assessment of exposed and sheltered parishes.

Map 4, Plate II shows the distribution of phthisis mortality amongst females in the parishes of Okehampton District. (The small white circular area in the centre of each map is

KEY-MAP OF THE PARISHES OF OKEHAMPTON RURAL DISTRICT

LIST OF PARISHES

1. Okehampton Urban District.
2. Okehampton (Rural).
3. Belstone.
4. Sampford Courtenay.
5. Exbourne.
6. Jacobstowe.
7. Inwardleigh.
8. South Tawton.
9. Throwleigh.
10. Chagford.
11. Drewsteignton.
12. Spreyton
13. North Tawton.
14. Bondleigh.
15. Honeychurch.
16. Broadwood Kelly.
17. Monkokehampton
18. Iddesleigh.
19. Meeth.
20. Highampton.
21. Hatherleigh.
22. North Lew.
23. Ashbury.
24. Beaworthy.
25. Germansweek.
26. Bratton Clovelly.
27. Sourton.
28. Bridestowe.
29. Uninhabited moorland.
30. Gidleigh.

Okehampton Urban District; it is omitted from consideration, attention being confined to the more comparable country villages.)

The distribution of the mortality can evidently not be explained by the geology. Differences of race, occupation, sanitation, or intermarriage do not enter into the question. Rainfall alone will not explain it. Yet the differences are very marked.

Turning, therefore, to wind-exposure, I have made maps of the wind-exposures of the parishes for each of the seven

directions—south-west, west, north-west, north, north-east, east, and south-east—one for each wind, tinting the fully exposed parishes dark brown, and the partly sheltered parishes light brown, leaving white the completely sheltered parishes (Maps 5 to 11, Plates II, III, and IV). The finer distinctions are difficult to draw in an intricately convoluted country ; and as partial shelter is the most difficult matter to assess, I would direct special attention to the complete exposures and complete shelters, which, at all events, can be depended upon. A coloured contour map, carefully studied parish by parish, for each wind separately, has been the means of comparison, and the method has been uniform for all the maps.

Taking these winds one by one—

Exposure to the north wind (Map 8) obviously will not explain the phthisis distribution, and this is confirmed by Table XXIV.

The effect of the north-east wind (Map 9) is almost the reverse of what we should expect if it increased phthisis death-rate. See also Table XXV.

The east and south-east winds (Maps 10 and 11) are also seen to be incapable of explaining the phthisis distribution. See also Tables XXVI and XXVII.

The map of exposure to the south-west wind (Map 5), on the other hand, is strikingly like the map of phthisis death-rate, and an examination of Table XXVIII brings out—

(*a*) a remarkably higher mortality in exposed as compared with sheltered parishes ;

(*b*) an intermediate position occupied by partly sheltered parishes ;

(*c*) the rarity of exception.

Some death-rates, however, need explanation :

North Lew is fully exposed to the west wind.

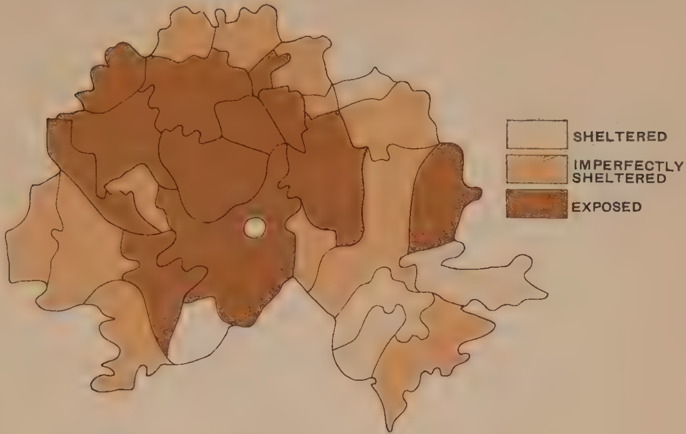
Exbourne is partly exposed to west wind and fully to north-west.

Beaworthy is the least exposed of the parishes classed as exposed.

Sampford Courtenay stands high, and besides being fully exposed to the north-west, gets perhaps more south-west than its neighbours over the corner of Dartmoor.

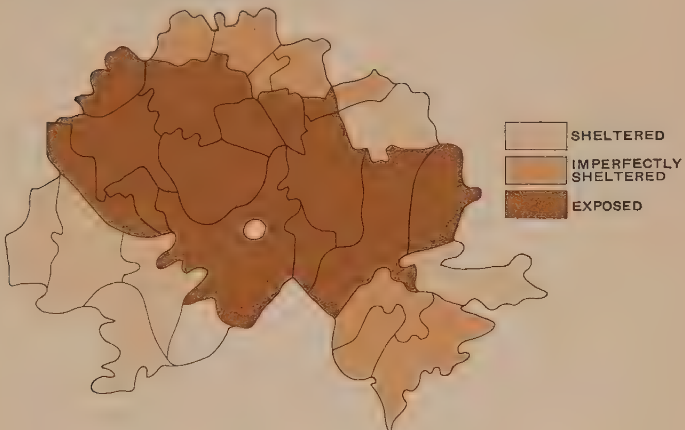
OKEHAMPTON RURAL DISTRICT
Exposure and Shelter of the Parishes in North-west Wind

Map 7



OKEHAMPTON RURAL DISTRICT
Exposure and Shelter of the Parishes in North Wind

Map 8



OKEHAMPTON RURAL DISTRICT
Exposure and Shelter of the Parishes in North-east Wind

Map 9

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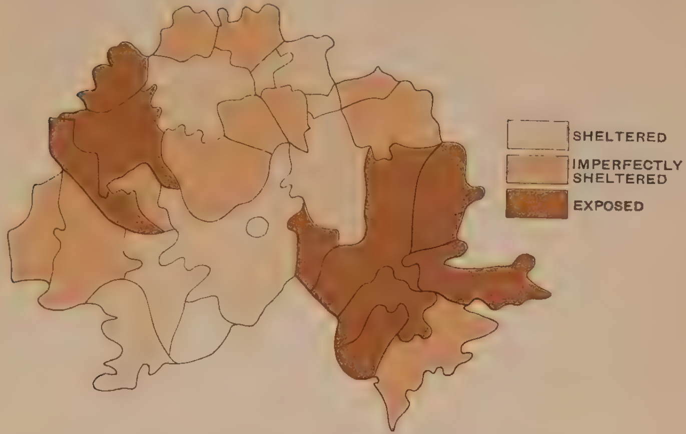
OKEHAMPTON RURAL DISTRICT
Exposure and Shelter of the Parishes in East Wind

Map 10



OKEHAMPTON RURAL DISTRICT
Exposure and Shelter of the Parishes in South-east Wind

Map 11

GEOLOGY OF OKEHAMPTON RURAL DISTRICT

Map 12

To face Page 42 behind Plate III

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TABLE XXIV

Influence of Exposure to North Wind

Name of parish.	Female population, 1891.	Female deaths from phthisis in ten years.	Female phthisis death-rate per 1,000 per annum.
I. SHELTERED PARISHES:			
North Tawton . . .	927	12	1·3
Drewsteignton . . .	378	3	·8
Bridestowe . . .	309	5	1·6
Bratton Clovelly . .	255	8	3·1
Sourton	217	8	3·6
	2,086	36	1·7 nearly
II. EXPOSED PARISHES:			
Highampton . . .	135	5	3·7
Beaworthy . . .	122	3	2·4
Hatherleigh . . .	724	6	·8
North Lew . . .	364	10	2·7
Jacobstowe . . .	113	2	1·7
Exbourne . . .	167	4	2·4
Sampford Courtenay .	429	11	2·5
Spreyton	193	3	1·5
Belstone	89	1	1·1
South Tawton . . .	633	9	1·4
Okehampton . . .	300	4	1.3
Ashbury	37	0	0
Inwardleigh . . .	258	1	·4
	3,564	59	1·6
III. IMPERFECTLY SHELTERED PARISHES:			
Meeth	91	1	1·1
Iddesleigh . . .	197	3	1·5
Monkokehampton . .	83	0	0
Broadwood Kelly . .	132	1	·7
Throwleigh . . .	149	2	1·3
Gidleigh	57	0	0
Chagford	728	7	.9
Germansweek . . .	102	4	3·9
Honeychurch . . .	17	0	0
Bondleigh . . .	67	0	0
	1,623	18	1·1

TABLE XXV

Influence of Exposure to North-East Wind

Name of parish.	Female population, 1891.	Female deaths from phthisis in ten years.	Female phthisis death-rate per 1,000 per annum.
I. SHELTERED PARISHES :			
Iddesleigh	197	3	1·5
Hatherleigh	724	6	·8
Monkokehampton	83	0	0
North Tawton	927	12	1·3
Bridestowe	309	5	1·6
Bratton Clovelly	255	8	3·1
Germansweek	102	4	3·9
Honeychurch	17	0	0
	2,614	38	1·4
II. EXPOSED PARISHES :			
South Tawton	633	9	1·4
Spreyton	193	3	1·5
Chagford	728	7	·9
Gidleigh	57	0	0
Belstone	89	1	1·1
Okehampton	300	4	1·3
Ashbury	37	0	0
Inwardleigh	258	1	·4
Beaworthy	122	3	2·4
North Lew	364	10	2·7
Highampton	135	5	3·7
	2,916	43	1·4
III. IMPERFECTLY SHELTERED PARISHES :			
Meeth	91	1	1·1
Broadwood Kelly	132	1	·7
Jacobstowe	113	2	1·7
Exbourne	167	4	2·4
Sampford Courtenay	429	11	2·5
Drewsteignton	378	3	·8
Throwleigh	149	2	1·3
Sourton	217	8	3·6
Bondleigh	67	0	0
	1,743	32	1·8

TABLE XXVI

Influence of Exposure to East Wind

Name of parish.	Female population, 1891.	Female deaths from phthisis in ten years.	Female phthisis death-rate per 1,000 per annum.
I. Sheltered Parishes :			
Hatherleigh . . .	724	6	·8
Monkokehampton . .	83	0	0
Broadwood Kelly . .	132	1	·7
Okehampton . . .	300	4	1·3
Honeychurch . . .	17	0	0
Sampford Courtenay .	429	11	2·5
Bridestowe . . .	309	5	1·6
Sourton	217	8	3·6
	2,211	35	1·5
II. Exposed Parishes :			
Highampton . . .	135	5	3·7
Beaworthy . . .	122	3	2·4
North Lew . . .	364	10	2·7
Spreyton	193	3	1·5
South Tawton . . .	633	9	1·4
Drewsteignton . . .	378	3	·8
Throwleigh . . .	149	2	1·3
Gidleigh	57	0	0
Belstone	89	1	1·1
	2,120	36	1·7
III. Imperfectly Sheltered Parishes :			
Meeth	91	1	1·1
Iddesleigh . . .	197	3	1·5
Inwardleigh . . .	258	1	·4
Jacobstowe . . .	113	2	1·7
Exbourne . . .	167	4	2·4
Bondleigh . . .	67	0	0
North Tawton . . .	926	12	1·3
Chagford	728	7	·9
Bratton Clovelly . .	255	8	3·1
Germansweek . . .	102	4	3·9
Ashbury	37	0	0
	2,942	42	1·4

TABLE XXVII

Influence of Exposure to South-East Wind

Name of parish.	Female population, 1891.	Female deaths from phthisis in ten years.	Female phthisis death-rate per 1,000 per annum.
I. SHELTERED PARISHES:			
Bridestowe	309	5	1·6
Sourton	217	8	3·6
Okehampton	300	4	1·3
Ashbury	37	0	0
North Lew	364	10	2·7
Hatherleigh	724	6	·8
Monkokehampton	83	0	0
Inwardleigh	258	1	·4
Jacobstowe	113	2	1·7
Exbourne	167	4	2·4
Honeychurch	17	0	0
Bondleigh	67	0	0
Sampford Courtenay	429	11	2·5
South Tawton	633	9	1·4
Drewsteignton	378	3	·8
Chagford	728	7	·9
Gidleigh	57	0	0
Throwleigh	149	2	1·3
Belstone	89	1	1·1
	5,119	73	1·4
II. EXPOSED PARISH:			
Spreyton	193	3	1·5
III. IMPERFECTLY SHELTERED PARISHES:			
Germansweek	102	4	3·9
Bratton Clovelly	255	8	3·1
Beaworthy	122	3	2·4
Highampton	135	5	3·7
Meeth	91	1	1·1
Broadwood Kelly	132	1	·7
Iddesleigh	197	3	1·5
North Tawton	927	12	1·3
	1,961	37	1·8

TABLE XXVIII

Influence of Exposure of South-West Wind

Name of parish.	Female population, 1891	Female deaths from phthisis in ten years.	Female phthisis death-rate per 1,000 per annum.
I. SHELTERED PARISHES:			
Chagford	728	7	·9
Gidleigh	57	0	0
Throwleigh	149	2	1·3
Drewsteignton	378	3	·8
South Tawton	633	9	1·4
Okehampton	300	4	1·3
Belstone	89	1	1·1
Jacobstowe	113	2	1·7
Exbourne	167	4	2.4
Inwardleigh	258	1	·4
North Lew	364	10	2·7
Ashbury	37	0	0
Hatherleigh	724	6	·8
Monkokehampton	83	0	0
	4,080	49	1·2
II. EXPOSED PARISHES:			
Highampton	135	5	3·7
Beaworthy	122	3	2·4
Germansweek	102	4	3·9
Bratton Clovelly	255	8	3·1
Sourton	217	8	3·6
	831	28	3·3
III. IMPERFECTLY SHELTERED PARISHES:			
Spreyton	193	3	1·5
Sampford Courtenay	429	11	2·5
North Tawton	927	12	1·3
Bondleigh	67	0	0
Honeychurch	17	0	0
Broadwood Kelly	132	1	·7
Iddesleigh	197	3	1·5
Meeth	91	1	1·1
Bridestowe	309	5	1·6
	2,362	36	1·5

TABLE XXIX

Influence of Exposure to West Wind

Name of parish.	Female population, 1891.	Female deaths from phthisis in ten years.	Female phthisis death-rate per 1,000 per annum.
I. SHELTERED PARISHES :			
Ashbury	37	0	0
Monkokehampton . .	83	0	0
Drewsteignton . . .	378	3	·8
Throwleigh . . .	149	2	1·3
Gidleigh	57	0	0
Chagford	728	7	·9
Inwardleigh . . .	258	1	·4
	1,690	14	·8
II. EXPOSED PARISHES :			
Bratton Clovelly . .	255	8	3·1
Beaworthy . . .	122	3	2·4
Highampton . . .	135	5	3·7
North Lew . . .	364	10	2·7
Broadwood Kelly . .	132	1	·7
Spreyton	193	3	1·5
Sourton	217	8	3·6
	1,418	38	2·6
III. IMPERFECTLY SHELTERED PARISHES :			
Bridestowe . . .	309	5	1·6
Germansweek . . .	102	4	3·9
Hatherleigh . . .	724	6	·8
Meeth	91	1	1·1
Iddesleigh . . .	197	3	1·5
North Tawton . . .	927	12	1·3
Honeychurch . . .	17	0	0
Sampford Courtenay .	429	11	2·5
South Tawton . . .	633	9	1·4
Belstone	89	1	1·1
Jacobstowe . . .	113	2	1·7
Exbourne . . .	167	4	2·4
Bondleigh . . .	67	0	0
Okehampton . . .	300	4	1·3
	4,165	62	1·4

The map (Map 6) dealing with exposures to west wind also suggests strikingly a connection between exposure and phthisis, though not so markedly as in the case of the south-west wind, and Table XXIX brings this out clearly.

Broadwood Kelly and Spreyton only get the wind after all its force has been broken, so that perhaps one is scarcely right in calling them fully exposed. Still, as there is doubt, it is better to give it against what suits one's theory rather than in its favour.

Germansweek is fully exposed to the south-west wind.

Next considering *south-west and west winds together*, Table XXX brings out the following remarkable facts:

1. That the mortality in the parishes fully exposed to both west and south-west winds is uniformly high—usually very high—whilst the mortality in the parishes fully sheltered from both is uniformly low—usually very low.

TABLE XXX

Influence of Exposure to West and South-West Winds

Name of parish.	Female population, 1891	Female deaths from phthisis in ten years.	Female phthisis death-rate per 1,000 per annum.
I. PARISHES SHELTERED FROM BOTH:			
Inwardleigh	258	1	·4
Monkokehampton . .	83	0	0
Chagford	728	7	·9
Gidleigh	57	0	0
Throwleigh . . .	149	2	1·3
Drewsteignton . . .	378	3	·8
Asbbury	37	0	0
	1,690	13	·7
II. PARISHES EXPOSED TO BOTH:			
Highampton	135	5	3·7
Beaworthy . . .	122	3	2·4
Bratton Clovelly . .	255	8	3·1
Sourton	217	8	3·6
	729	24	3·3 nearly

TABLE XXXI

Influence of Exposure to North-West Wind

Name of parish.	Female population, 1891.	Female deaths from phthisis in ten years.	Female phthisis death-rate per 1,000 per annum.
I. SHELTERED PARISHES:			
Bondleigh	67	0	0
Drewsteignton	378	3	·8
Throwleigh	149	2	1·3
Gidleigh	57	0	0
	651	5	·7
II. EXPOSED PARISHES:			
Hatherleigh	724	6	·8
Highampton	135	5	3·7
North Lew	364	10	2·7
Beaworthy	122	3	2·4
Inwardleigh	258	1	·4
Jacobstowe	113	2	1·7
Exbourne	167	4	2·4
Sampford Courtenay	429	11	2·5
Speyton	193	3	1·5
Monkokehampton	83	0	0
Okehampton	306	4	1·3
Sourton	217	8	3·6
	3,105	57	1·8
III. IMPERFECTLY SHELTERED PARISHES:			
Meeth	91	1	1·1
Iddesleigh	197	3	1·5
Honeychurch	17	0	0
North Tawton	927	12	1·3
South Tawton	633	9	1·4
Belstone	89	1	1·1
Chagford	728	7	·9
Germansweek	102	4	3·9
Bratton Clovelly	255	8	3·1
Bridestowe	309	5	1·6
Broadwood Kelly	132	1	·7
Ashbury	37	0	0
	3,517	41	1·1

2. That the average mortality in the exposed parishes is nearly five times as great as that in the sheltered parishes.

3. That there are no exceptions.

The influence of the *north-west wind* looks doubtful on the map (Map 7), but Table XXXI indicates that it has some effect. This effect is by no means so marked as that of the west and south-west winds, but it probably helps to account for the death-rates in Sampford Courtenay and Exbourne.

I would submit that there is here remarkable evidence in favour of a strong influence of south-west and west winds (the chief strong prevalent rain-bearing winds of Devonshire) on phthisis death-rate, and to a less degree in favour of some influence of the north-west, also a strong rain-bearing wind, but less rainy and less prevalent. The figures are very striking, and it is difficult to imagine that mere chance can explain them.

CHAPTER IV

THE INFLUENCE OF PREVALENT STRONG RAIN-BEARING WINDS ON THE FEMALE PHTHISIS MORTALITY (CALCULATED ON THE TOTAL POPULATION) IN EXETER STREETS DURING THE TEN YEARS 1892–1901

A FEW years ago a valuable report was issued by the sanitary authority of Exeter, dealing with the distribution of the phthisis death-rate in those streets of the city in which deaths from the disease had occurred during the decade 1892 to 1901. This report divides the streets into groups, according to the rateable value of the houses, and gives for every street, during the ten years in question, the number of inhabited houses, the population according to the census of 1901, the average height above sea-level, the direction of the street, its soil, its annual death-rate per 1,000 from all causes for the ten years, its annual death-rate per 1,000 from phthisis for the ten years, the deaths each year from all causes and from phthisis alone, and their totals in the ten years, together with the sex, age, and occupation of every person dying from phthisis in every year.

This report makes it possible to show not only

1. that those streets whose roadways are swept by the prevailing rainy winds, *viz.* south-west, west, and north-west, suffer more from phthisis than those whose roadways are sheltered from them, but also

2. that, where the streets are subdivided according to soils, the same contrast comes out between the exposed and the sheltered, and

3. that, when they are subdivided according to the rateable values of their houses, again the same result is reached.

4. It also enables one to prove that the influences of soil and of poverty (as estimated in terms of rateable values),

though real influences, are feebler than the influence of rain-bearing wind,

5. that general death-rate has no definite relation to the phthisis death-rate,

6. and gives some reason for believing that the influence of rain-bearing wind is exerted (at least in large measure) directly on the persons exposed to it, and not (at least to any great extent), as some have suggested, indirectly, either through closure of doors and windows against the wind or by its driving wet into the walls of the houses.

In dealing with these points, female deaths only are considered. Unfortunately, however, the female populations of the streets are not available, so that the female phthisis death-rates have had to be expressed in terms of the total mixed populations. The error thus introduced cannot be looked on as a serious one where a number of streets, with a considerable aggregate population, are grouped together, and certainly cannot be held to invalidate the striking results brought forward. It will be remembered, of course, that the figures so obtained should be about half the ordinary female death-rates. Deaths under five years of age have been excluded ; only two such were found—one in the sheltered, the other in the exposed streets. As soil must also be referred to, a few words are necessary about "made soil." This obviously cannot be regarded as uniform in composition. In Exeter it is associated generally with a very high phthisis death-rate, but the death-rates upon it seem to follow none of the laws which appear to determine the death-rates on clay, sandstone, and gravel. Consequently, its inclusion amongst other soils probably tends to obscure the results obtained on them. It will therefore be excluded wherever it can confuse.

The Influence of Wind

In Table XXXII. the streets are arranged in ascending order of female phthisis death-rates expressed in terms of their total population. It can be seen at a glance that streets with sheltered roadways (marked S) are commonest near the beginning, and that streets with exposed roadways (marked X) are commonest near the end of the table. The natural inference drawn from this table is confirmed by

Table XXXIII ; but to make additionally sure that the result is no chance one, the difference between shelter and exposure has been again investigated in groups of streets arranged according to soil (Table XXXIV), and again in groups of streets arranged according to rateable values (Table XXXV).

In view of such results, I would submit that there can be no reasonable doubt that, in Exeter, exposure of the roadway of a street to the prevalent rain-bearing winds increases its phthisis mortality.

THE INFLUENCE OF SOIL

In Table XXXII, which makes so obvious the influence of wind, the influence of soil is by no means obvious, and

TABLE XXXII

Phthisis in the Streets of Exeter, 1892 to 1901

Name of street.	Death-rate from phthisis among females (over 5 years of age) per 1,000 of total population per annum.	Shelter (S) or exposure (X) of roadway, as regards S.W., W., or N.W. wind.	Soil.	Rateable value of inhabited houses in £ per annum.	Total female phthisis deaths over 5 years of age, 1892–1901.	Total population, census 1901.
St. Leonard's Rd.	0	½S	Gravel	Over 30	0	324
Roberts Rd.	0	?	Clay	8–10	0	233
Springfield Rd.	0	S	,,	10–15	0	208
Haldon Rd.	0	S	Shillet	25–30	0	189
Cowley Rd.	0	X	,,	Over 30	0	177
Wierfield Rd.	0	X	Gravel	8–10	0	174
Codrington St.	0	S	Clay	,,	0	160
Salisbury Rd.	0	½X	,,	10–15	0	157
Waterbeer St.	0	S	Sandstone	8 and under	0	147
Friernhay St.	0	S	Made	,,	0	143
May Rd.	0	X	Clay	8–10	0	141
Red Cow Village	0	X	Shillet	8 and under	0	135
Ewing's St.	0	S	Gravel	,,	0	127
Dean St.	0	?	Clay	8–10	0	120
St. Sidwell's Aven.	0	S	Sandstone	10–15	0	119
Topsham Rd.	0	½X	Not stated	Over 30	0	119
Temple Rd.	0	½X	Clay	10–15	0	115
York Rd.	0	S	Sandstone	Over 30	0	108
Albert St.	0	S	Clay	8–10	0	104
Goldsmith St.	0	S	,,	25–30	0	98
Elmgrove Rd.	0	½X	,,	Over 30	0	93

TABLE XXXII (*continued*)

Name of street.	Death-rate from phthisis among females (over 5 years of age) per 1,000 of total population per annum.	Shelter (S) or exposure (X) of roadway, as regards S.W., W., or N.W. wind.	Soil.	Rateable value of inhabited houses in £ per annum.	Total female phthisis deaths over 5 years of age, 1892–1901.	Total population, census 1901.
Guinea St. . .	0	S	Clay	8–10	0	76
Edmund St. .	0	X	Made	8 and under	0	73
Cricklepit St. .	0	S	,,	,,	0	70
Franklyn St. .	0	?	,,	8–10	0	69
Gandy St. . .	0	S	Clay	20–25	0	66
Centre St. . .	0	S	Gravel	8 and under	0	51
Bear St. . .	0	S	Clay	,,	0	39
George St. . .	0	S	Sandstone	10–15	0	26
John St. . .	0	S	,,	over 30	0	14
Southernhay .	0·1	?	Made	,,	1	506
Well St. . .	0·2	S	Sandstone	8–10	1	450
Victoria Rd. .	0·2	¾S	Clay	10–15	1	432
Clifton Rd. & Hill	0·2	½S	,,	,,	1	410
Friar's Walk .	0·2	¾S	Clay and pebble	15–20	1	399
Cheeke St. . .	0·2	S	Clay	8 and under	1	353
Longbrook St. .	0·2	S	,,	20–25	1	335
Magdalen St. .	0·3	?	Clay and shillet	10–15	3	882
Hoopern St. .	0·3	S	Clay	8–10	1	316
James St. . .	0·3	½X	,,	8 and under	1	253
Tiverton Rd. .	0·4	X	,,	20–25	3	640
E. John St. .	0·4	½X	,,	8–10	2	478
High St. . .	0·4	X	Sandstone	over 30	2	465
Parr St. . .	0·4	?	Clay	8 and under	2	459
Wonford Rd. .	0·4	½X	Gravel	20–25	2	419
Frog St. . .	0·4	S	,,	8 and under	1	229
Dinham Rd. .	0·4	X	Shillet	10–15	1	228
New North Rd. .	0·4	X	Made	25–30	1	205
Paris St. . .	0·5	S	Clay	10–15	6	1,024
Summerland St. .	0·5	½S	Sandstone	8–10	4	728
Portland St. .	0.5	½X	Clay	10–15	3	554
Sun St. . .	0·5	?	Clay and shingle	8–10	2	366
Howell Rd. .	0·5	?	Clay and shillet	20–25	2	336
Melbourne St. .	0·5	X	Clay and shingle	8–10	1	197
Culverland Rd. .	0·5	S	Clay	10–15	1	179
New Bridge St. .	0·5	X	Made	25–30	1	172
Belgrave Rd. .	0·5	S	Clay	8 and under	1	171
Lion's Holt .	0·5	½X	,,	,,	1	170
Sidwell St. . .	0·6	X	Sandstone	15–20	11	1,845
Blackboy Rd. .	0·6	X	Clay	10–15	6	971
St. David's Hill .	0·6	X	Shillet	25–30	4	615
Fore St. . .	0·6	X	Sandstone	Over 30	3	454
South St. . .	0·6	?	Clay and shillet	20–25	3	441
Mary Arches St. .	0·6	¾X	Made	8–10	2	321

TABLE XXXII (*continued*)

Name of street.	Death-rate from phthisis among females (over 5 years of age) per 1,000 of total population per annum.	Shelter (S) or exposure (X) of roadway, as regards S.W., W., or N.W. wind.	Soil.	Rateable value of inhabited houses in £ per annum.	Total female phthisis deaths over 5 years of age, 1892–1901.	Total population, census 1901.
Blackall Rd. .	0·6	X	Clay	Over 30	1	156
Preston St. . .	0·7	X	Gravel	8–10	4	571
Coombe St. .	0·7	X	Made	8 and under	4	525
Rack St. . .	0·7	X	Clay and shingle	,,	3	422
Russell St. . .	0·7	S	Clay	8–10	3	398
Stepcote Hill .	0·7	X	Clay and shingle	8 and under	3	381
Northernhay St. .	0·7	½X	Not stated	10–15	2	285
Bonhay Rd. .	0·7	X	Clay and shillet	8–10	2	252
Cathedral Yard .	0·7	½X	Made	Over 30	1	140
Raleigh Rd. .	0·7	?	Clay	20–25	1	139
Market St. . .	0·7	S	,,	10–15	1	127
Clifton St. . .	0·8	½X	,,	8 and under	4	477
Exe Island . .	0·8	X	Gravel	,,	2	230
Belmont Rd. .	0·8	S	Clay	20–25	2	230
Polsloe Rd. .	0·8	?	,,	Over 30	1	117
Bartholomew St.	0·9	X	Shillet	10–15	9	1,100
Exe St. . .	0·9	X	Gravel	8 and under	5	550
Pennsylvania .	0·9	X	Clay	Over 30	5	525
Catherine St. .	0·9	?	,,	15–20	1	105
Rosebery Rd. .	1·0	X	,,	10–15	2	193
Oxford Rd. .	1·2	X	,,	15–20	3	238
King St. . .	1·2	S	Sandstone	8 and under	2	163
Church Lane .	1·2	½X	Clay	8–10	1	83
North St. . .	1·3	X	Made	10–15	8	564
Sandford St. .	1·3	½X	Clay	8 and under	7	513
Commercial Rd. .	1·3	X	Gravel	,,	5	359
Radford Rd. .	1·3	¾X	Made	8–10	4	299
Mt. Radford Sq. .	1·3	S	,,	8 and under	1	77
Holloway St. .	1·4	?	Clay and shillet	10–15	9	607
Paul St. . .	1·4	X	Clay and shingle	8–10	7	479
Smythen St. .	1·4	X	,,	,,	3	210
Jubilee St. . .	1·4	X	Alluvial	8 and under	2	135
West Quarter .	1·5	X	Sandstone	8–10	7	462
Queen Street .	1·6	X	Made	Over 30	4	250
Chute St. . .	1·7	S	Clay	8–10	3	168
Devonshire Place	1·7	X	,,	20–25	2	114
St. James's Rd. .	2·0	X	,,	25–30	1	49
Quay Lane . .	2·1	X	Clay and shingle	8 and under	5	238
Pancras Lane .	2·3	S	Made	,,	4	170
Tudor St. . .	2·5	?	Shillet	,,	5	197
Mansfield Rd. .	2·5	X	Clay	10–15	4	158
Castle St. . .	2·7	S	Made	15–20	4	167
Sidwella Cottages	3·8	X	Sandstone	10–15	1	26

TABLE XXXIII

(*Made Soil Excluded*)

	Population.	Female phthisis death-rate in terms of total population.
Sheltered streets . .	5,675	0·42 per 1,000
Exposed streets . .	12,521	0·82 per 1,000

Table XXXVI, constructed without first eliminating the influence of wind, indicates no influence of soil.[1] But, if

TABLE XXXIV

Soil.	Population.		Female phthisis death-rate in terms of total population.	
	Sheltered.	Exposed.	Sheltered.	Exposed.
Gravel . . .	407	1,884	0·24	0·84
Sandstone . .	1,027	3,252	0·29	0·73
Clay . . .	4,052	3,185	0·49	0·81
Made soil . . .	607	1,789	1·43	1·00

the effect of wind be first eliminated by only considering the sheltered streets, arranged in ascending order of phthisis

TABLE XXXV

(*Made Soil Excluded*)

Rateable value of houses.	Population.		Female phthisis death-rate in terms of total population.	
	Sheltered.	Exposed.	Sheltered.	Exposed.
£8 and under . .	1,280	2,450	0·39	1·02
£8 to £10 . . .	1,672	2,486	0·47	0·96
£10 to £15 . .	1,683	2,676	0·47	0·85
Over £20 . . .	1,040	3,195	0·28	0·65

There are no sheltered streets except on made soil at £15 to £20

death-rates as in Table XXXVII, an influence of soil at once suggests itself; and this suggestion is strongly supported by

[1] Except in the case of "made soil" already referred to, on which, as has been pointed on, no stress can be laid.

TABLE XXXVI

Soil.	Population.	Female phthisis death-rate in terms of total population.
Gravel	3,034	0·62
Sandstone	5,007	0·60
Clay	12,237	0·58
Made soil	3,731	0·93

TABLE XXXVII

Female Phthisis Death-rates in the Sheltered Streets of Exeter, from 1892 *to* 1901

Name of Street.	Female phthisis death-rate (over five years of age) per 1,000 of total population per annum.	Soil.	Rateable value of inhabited houses in £ per annum.	Total female deaths from phthisis over five years of age, 1892 to 1901.	Total population, census 1901.
Springfield Road	0	Clay	10–15	0	208
Haldon Road		Shillet	25–30		189
Codrington Street		Clay	8–10		160
Waterbeer Street		Sandstone	8 and under		147
Ewings Street		Gravel	,, ,,		127
St. Sidwell's Avenue		Sandstone	10–15		119
York Road		,,	over 30		108
Albert Street		Clay	8–10		104
Goldsmith Street		,,	25–30		98
Guinea Street		,,	8–10		76
Gandy Street		,,	20–25		66
Centre Street		Gravel	8 and under		51
Bear Street		Clay	,, ,,		39
George Street		Sandstone	10–15		26
John Street		,,	over 30		14
Well Street	0·2	,,	8–10	1	450
Cheeke Street	0·2	Clay	8 and under	1	353
Longbrooke Street	0·2	,,	20–25	1	335
Hoopern Street	0·3	,,	8–10	1	316
Frog Street	0·4	Gravel	8 and under	1	229
Paris Street	0·5	Clay	10–15	6	1,024
Culverland Road	0·5	,,	10–15	3	179
Belgrave Road	0·5	,,	8 and under	1	171
Russell Street	0·7	,,	8–10	3	398
Market Street	0·7	,,	10–15	1	127
Belmont Road	0·8	,,	20–25	2	230
King Street	1·2	Sandstone	8 and under	2	163
Chute Street	1·7	Clay	8–10	3	168

the column of Table XXXIV, which deals with these sheltered populations. Soil, in fact, appears to have a very distinct influence, but one so much weaker than that of wind as to be entirely masked by the latter.

The Influence of Poverty

Like the influence of soil, the influence of poverty (as deduced from the rateable values) is not apparent in Table XXXII, but Table XXXVIII, dealing with all the streets together, exposed as well as sheltered, suggests that it probably exists. To make certain of this, however, the influence of wind and soil should be eliminated.

Table XXXV. shows the variations in phthisis death-rate

TABLE XXXVIII

Rateable Value.	Population.	Female phthisis death-rate in terms of total population.
£8 and under . . .	6,857	0·81
£8 to £10	6,855	0·65
£10 to £15 . . .	8,365	0·60
£15 to £20 . . .	2,734	0·69
£20 to £25 . . .	2,720	0·51
£25 to £30 . . .	1,328	0·52
Over £30	3,448	0·52

with variations in rateable value in sheltered and exposed streets separately. The exposed streets bear out the indication of Table XXXVIII, but, as exposure varies considerably in degree, no stress can be laid on this. The sheltered streets do not at first sight seem to bear out the indication, because the poorest have a relatively low death-rate. But on closer examination this discrepancy disappears; for these poorest streets happen to be built on the most generally pervious soil. Table XXXIX makes this clear, and if the relative death-rates in shelter on clay, gravel, and sandstone are borne in mind, it will be seen that rateable value has a distinct influence on phthisis death-rate. In this table an attempt is made to "correct" the death-rates for soil by expressing them all in terms of clay soil only; using for this purpose the relative values for clay, gravel, and sand-

stone indicated in Table XXXIV (sheltered streets); needless to say, no stress is laid on the exact figures so obtained, but this column of the table at least serves to indicate the influence of rateable value more clearly than can otherwise be done. Apparently at rateable values of £15 and under there is little difference in phthisis death-rates, but there is a very marked contrast between streets of rateable values at and below £15 a year and streets of rateable values over £20 a year, the poorer streets showing a death-rate 66 per cent. higher than the richer.

To compare this influence of poverty with the influence of rain-bearing winds, one may reason as follows. In the exposed streets, the poorer streets (rateable value under £15) have a phthisis death-rate only 12 per cent. higher than the richer streets (rateable values over £20). But when all streets, exposed and sheltered, are considered together, the poorer have a phthisis death-rate 24 per cent. higher than the richer and, when only sheltered streets are compared, the poorer, as has just been shown, have a mortality 66 per cent. higher than the richer.

The influence of rainy wind, therefore, tends strongly to mask the influence of poverty in Exeter, although it does not wholly mask it as it does the influence of soil. On the other hand, the influence of poverty is clearly unable to mask the influence of rainy winds.

Absence of the Influence of General Death-rate.

The figures in the report give no indication that general death-rate has any effect on phthisis death-rate. Table XL is an attempt to disentangle general death-rate from other influences. Only sheltered streets of rateable values under £15 a year are considered, so as to eliminate the influences of wind and of poverty (which latter, we have just seen, seems to produce little difference of phthisis death-rate under £15 a year rateable value), and the percentage on clay is stated, the rest of them being on gravel and sandstone. At first sight it would seem as if high general death-rate went with low phthisis death-rate, but when a rough "correction" is made for soil (as was done in Table XXXIX) the

TABLE XXXIX

(*Made Soil Excluded.*) *Sheltered Streets only*

Rateable value.	Proportion of population on			Death-rate corrected for soil, that is, to what it should be for uniform clay soil.
	Clay.	Sandstone.	Gravel.	
	Per cent.	Per cent.	Per cent.	
£8 and under .	44	25	31	0·57
£8 to £10 . .	74	26	—	0·55
£10 to £15 . .	92	8	—	0·50
Over £20 . .	88	12	—	0·33

death-rates obtained in the last column are, curiously, nearly identical. Without laying any stress on such "corrected" values, it may be safely said that there is no evidence in Exeter that general death-rate exerts any influence on phthisis death-rate.

Conclusion

Finally, in order to obtain a complete idea of the effect of wind-exposure we may use the information now acquired regarding soil and poverty in shelter. Table XLI compares the streets which are most completely sheltered with those which seem specially wind-swept by the rainy winds. The influence of soil is eliminated by considering only streets which are on clay soil. That of poverty may be eliminated as far as possible by allowing for the percentage of the population, in each set of streets, which resides in houses under £15 and over £20. Even if we leave rateable value out of account, the death-rate in the exposed streets is

TABLE XL

(*Made Soil Excluded.*) *Sheltered Streets only. Rateable Value under £15*

General death-rate.	Population.	Percentage on clay.	Female phthisis death-rate.	Female death-rate corrected for soil, roughly.
		Per cent.	Per cent.	
Under 15 per 1,000 . . .	1,375	10	0·58	0·64
Over 20 per 1,000 . . .	718	48	0·41	0·62

seen to be nearly four times as great as in the sheltered streets, and if we allow for rateable values the ratio becomes rather more than four to one.

This result reminds one of the ratio of five to one in Okehampton Rural District (Chapter III), and suffices to indicate that the influence of rainy wind is considerably greater than the influences of soil and poverty. This conclusion is important, because it makes possible an inquiry

TABLE XLI

(*Specially marked Shelter and Exposure, on Clay only*)

	Population.	Percentage.		Female phthisis death-rate as before.
		Under £15.	Over £20.	
Sheltered Streets.				
Cheeke Street, Albert Street . . Chute Street, Codrington Street . Guinea Street, Hoopern Street . Culverland Road, Gandy Street . Springfield Road, Goldsmith Street . Longbrook Street . . .	2,063	76	24	0·33
Exposed Streets.				
May Road, Mansfield Road . . Rosebery Road, Blackall Road . Oxford Road, Devonshire Place . St. James's Road, Pennsylvania .	1,684	30	70	1·18

into the effects of rainy winds in localities where the parts played by soil and poverty cannot be assessed.

Influence of Wind Probably Direct

In Exeter, Mr. Wreford, the sanitary inspector, assures me that the phthisis distribution cannot be explained by wet driven into the walls, because the newer houses have double walls, and 75 per cent. at least of the older houses have battened walls, which amount to the same thing.

Further, the streets which suffer most from phthisis are those along which the wind blows—that is, just those in which it does not drive directly against doors, windows, and walls; and again, since the streets which suffer most

are those whose roadways are exposed, it seems natural to conclude that the rainy wind exerts its influence on the people themselves as they pass along these roadways.

My best thanks are due to Mr. Wreford, for most kindly placing at my disposal the invaluable assistance of his long and intimate knowledge of all parts of the city, and especially for corroborating my classification of the streets into sheltered and exposed as regards the winds.

CHAPTER V

THE INFLUENCE OF PREVALENT STRONG RAIN-BEARING WINDS ON THE FEMALE PHTHISIS MORTALITY IN TWENTY-THREE PARISHES OF NORTH DEVON DURING THE FORTY-FIVE YEARS 1860-1904.

THE Exmoor part of Barnstaple Rural District is particularly well suited to an inquiry into the influence of westerly winds on the prevalence of phthisis over a considerable period of time. In carrying out the necessary investigation I had the great advantage of the help of Dr. J. R. H. Harper, the resident Medical Officer of Health.

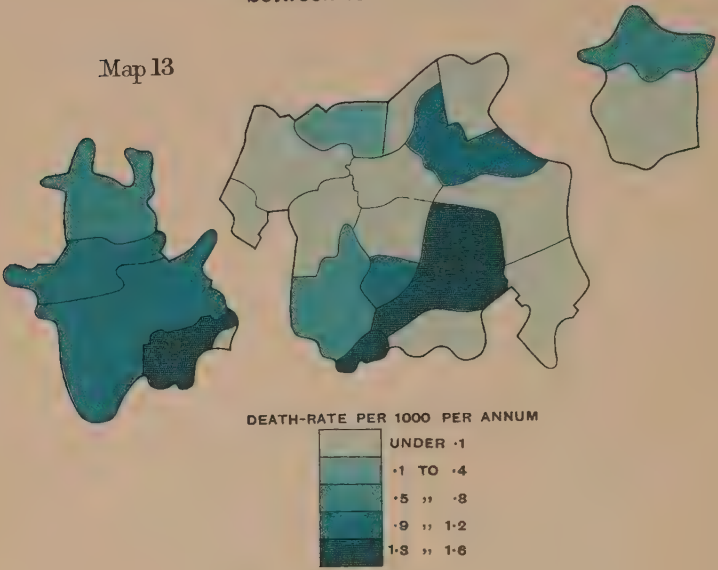
The district is known to both of us and intimately known to Dr. Harper. It presents exceptionally marked contrasts of shelter from, and exposure to, the prevalent strong rain-bearing winds—south-west, west, and north-west; its weather has been carefully observed, the characters of its soils can be satisfactorily stated, its inhabitants are of uniform race, the district is agricultural, and parish sanitation may be taken as uniform.

The parishes we chose were selected because of the definiteness of their shelter and exposure. It is not pretended that either shelter or exposure is absolute in any of them—probably none are *absolutely* sheltered in all conditions of weather—but the contrasts between the "sheltered" parishes and the "exposed" is at least exceedingly marked, much more marked than can be found in most English counties. Only female deaths over five years of age were considered. Cases dying in hospitals or in workhouses were, as far as possible, referred to the parishes they came from, and error from that source, if existent, must be very small.

Seeing that diagnosis may reasonably be expected to have been more accurate, since Koch's discovery in 1881 of the tubercle bacillus simplified the conception of phthisis, the

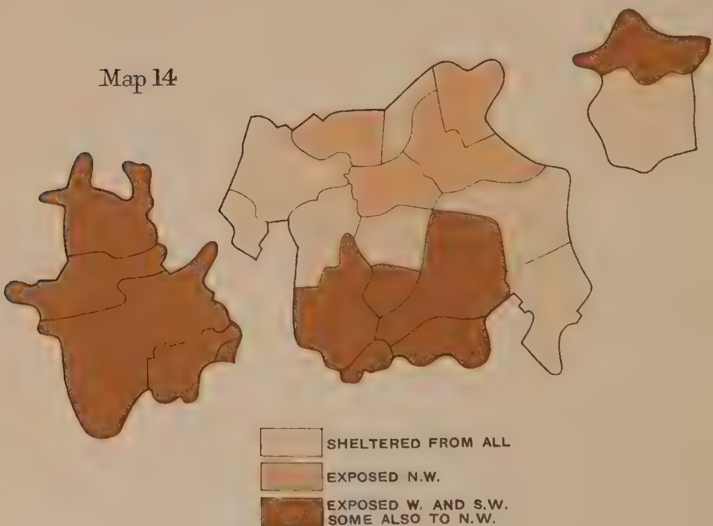
BARNSTAPLE RURAL DISTRICT
Phthisis Death-rates among Females in Twenty-three Parishes between 1890 and 1899

Map 13



BARNSTAPLE RURAL DISTRICT
Exposure and Shelter of the Parishes in Westerly Winds

Map 14



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twenty years, 1885 (by which time knowledge of this discovery must have been general) to 1904 were also separately considered. As the weather conditions during the ten years, 1890 to 1899, were exceptional, the rainfall being low and the frequency of the north-west wind relatively much reduced, those years also were considered especially by themselves.

Description of Parishes

The district under discussion forms, roughly, the western half of Exmoor, and is an irregular oblong, bounded on the

Key-map of the 23 Parishes, Showing also the Positions of the Parishes of Ilfracombe (2) and Lynton (8)

LIST OF PARISHES

1. Morthoe.
2. Ilfracombe.
3. Bittadon.
4. Berrynarbor.
5. Combemartin.
6. Trentishoe.
7. Martinhoe.
8. Lynton.
9. Countisbury.
10. Brendon.
11. Challacombe.
12. Highbray.
13. Stoke Rivers.
14. Bratton Fleming.
15. Parracombe.
16. Kentisbury.
17. Arlington.
18. Loxhore.
19. Goodleigh.
20. Sherwill.
21. East Down.
22. Georgeham.
23. Braunton.
24. Heanton Punchardon.
25. Ashford.

north and west by the Bristol Channel, on the south by the estuary of the Taw, as far as Barnstaple, and—east of Barnstaple—by an irregular line running eastwards over the foothills of the moor, to meet another, equally irregular, part of the eastern boundary of the county, which strikes northwards

over the heights of Exmoor Forest to the coast. It is a country of steep hills and rapid streams, so that surface drainage is naturally good. The northern coast line is for the most part precipitous, broken here and there by deep and often wooded combes, but westward the hills fall gradually to a low, sandy shore, as they also do southwards to the level banks of the Taw and the meadows round Barnstaple. East of Barnstaple the ground rises steeply, and becomes part of the convoluted tableland of the moor, which slopes gradually upwards from west to east.[1] The position of the parishes is shown in the key-map on p. 65.[2]

This district is composed of the following materials:

1. Igneous rock, in patches, impervious.
2. Argillaceous slates
3. Morte slates } impervious, apt to become clayey.
4. Ilfracombe beds
5. Lynton beds } less impervious than 2 and 3.
6. Pilton slates
7. Hangman grits
8. Baggy beds
9. Foreland grits } all very pervious.
10. Pickwell Down sandstone

The extent to which these enter into the structure of each parish will be presently considered.

The annual prevalence of the different winds at Barnstaple since 1870 is given in Table XLII, the annual rainfall at Barnstaple since 1860 in Table XLIII., and the rainfall at various points in or close to the district during 1901 to 1904 in Table XLIV. The inclusion of a few outside stations in Table XLIV helps to make clear the distribution of the fall.

Soil and Exposure or Shelter of Parishes

In the following brief statement the parishes have been arranged (as they will be in the subsequent tables) approxi-

[1] A good idea of the district can be gained from Bartholomew's reduced Ordnance Survey coloured contour map of North Devon, scale two miles to an inch, and from Map 1.

[2] West Down (included as "sheltered" from south-west and west in Table IV, Chapter I) has been omitted because its position seems doubtful. Pilton, exposed to south-west and west (also included in Table IV), has also been omitted, because in the forty-five years its boundaries have considerably altered.

TABLE XLII

*Direction of the Wind at Barnstaple at 9 a.m.**

Year.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
1870	17	48	41	49	31	74	54	51
1871	—	—	—	—	—	—	—	—
1872	14	22	6	50	67	104	62	41
1873	12	23	37	43	58	89	55	48
1874	24	20	26	37	53	81	66	58
1875	23	34	51	40	61	71	55	30
1876	19	36	30	60	52	72	59	38
1877	15	18	28	40	56	94	57	57
1878	32	23	28	45	38	90	55	54
1879	22	39	31	53	49	76	46	49
1880	23	51	39	49	52	69	60	23
1881	16	46	33	37	49	77	69	38
1882	19	27	21	44	57	86	56	55
1883	26	31	26	36	67	63	61	55
1884	17	24	34	45	57	68	70	51
1885	33	44	34	39	52	67	52	44
1886	13	50	34	34	56	56	65	57
1887	33	58	43	20	42	68	44	57
1888	15	34	57	47	36	69	73	35
1889	8	23	42	35	26	83	86	62
1890	12	37	75	92	30	42	50	27
1891	12	18	93	79	38	53	61	11
1892	18	30	84	60	40	60	48	26
1893	16	30	101	55	37	50	57	19
1894	13	36	51	83	31	51	57	33
1895	6	45	75	52	41	72	40	34
1896	16	71	74	29	48	72	30	26
1897	8	52	77	48	49	86	21	24
1898	7	72	70	49	67	63	17	20
1899	6	46	70	51	61	96	23	12
1900	9	28	35	76	38	62	62	55
1901	7	32	66	107	27	24	41	61
1902	14	19	46	93	25	32	87	49
1903	6	20	23	99	32	49	76	60
1904	7	9	41	121	25	37	77	49
Total .	538	1,200	1,625	1,886	1,562	2,306	1,892	1,409
Total number of days							12,418	

* Kindly prepared for Dr. Harper and myself by Mr. Wainwright.

mately in order of shelter and exposure, beginning with the most sheltered and ending with the most exposed. In assessing shelters and exposures local knowledge has been laboriously supplemented by study of the Ordnance Survey maps, 1 in. and 6 in. to the mile.

Bittadon.—A very small parish, very well sheltered from

TABLE XLIII

Rainfall at Barnstaple *

Year	Inches.	Year.	Inches.	Year.	Inches.	Year.	Inches.	Year.	Inches.
1860	50·14	1870	28·79	1880	42·99	1890	29·67	1900	40·26
1861	37·15	1871	38·00	1881	38·09	1891	32·30	1901	33·40
1862	43·78	1872	57·96	1882	53·71	1892	25·99	1902	32·40
1863	40·17	1873	39·30	1883	44·24	1893	32·02	1903	45·76
1864	26·43	1874	41·96	1884	37·97	1894	38·26	1904	35·21
1865	39·36	1875	45·34	1885	37·71	1895	33·78		
1866	43·02	1876	39·95	1886	45·03	1896	32·01		
1867	39·34	1877	49·53	1887	29·43	1897	42·26		
1868	39·94	1878	44·08	1888	34·29	1898	31·62		
1869	39·72	1879	39·35	1889	30·86	1899	33·13		

* Kindly prepared for Dr. Harper and myself by Mr. Wainwright.

S.W., W., and N.W. winds. Except for a small patch of igneous rock, its soil is composed of argillaceous slate.

Brendon.—A large parish, mostly moorland, with its dwellings very well sheltered from S.W., W., and N.W. winds. The village stands on Lynton beds; the parish generally is on Lynton grits and slates.

Highbray.—The whole parish may be regarded as well sheltered from S.W., W., and N.W. winds. The village is on Baggy beds, the extreme north of the parish on Morte slates, the centre and greater part of it on Pickwell Down sandstone with bands of argillaceous slate, and the southern part on slates, passing into grits and sandstones.

Challacombe.—Excepting one farm exposed to the N.W., this parish is sheltered from S.W., W., and N.W. The village is on the boundary between Ilfracombe beds and Morte slates. The north of the parish is on slate, with bands of limestone (Ilfracombe beds), and the southern part on argillaceous slate.

Trentishoe.—The houses are all sheltered from S.W., W., and N.W., but in some places a short walk from a house leads into a very exposed situation. The village is on Hangman grits, and these and Ilfracombe beds form the soil of the parish.

Berrynarbor.—A long, straggling village, in a combe running up southwards from the Bristol Channel. It is well sheltered from S.W. and W., and most of it from N.W.; but some houses are exposed to N.W. The parish is on Ilfracombe beds.

Arlington.—The village is well sheltered from S.W. and W.; not quite so well from N.W. The east of the parish is well sheltered from all three, but some houses in its western part are open to W. and N.W. The village is on Morte slates, as is also the parish generally, except its southern part, which is partly composed of Pickwell Down sandstone.

TABLE XLIV

Rainfall at Several Places in and near the District

Station.	Height in feet.	Rainfall in Inches.			
		1901.	1902.	1903.	1904.
Lynmouth (Rock Ho.)	20	33·6	34·0	58·3	39·0
Barnstaple	25	33·4	32·4	45·7	35·2
Ilfracombe	35	36·1	33·3	53·2	37·0
Woollacombe	60	26·6	25·3	38·3	28·2
Pilton	83	..	33·3	47·6	35·6
Lynmouth (Gwynallt)	300	38·0	35·9	61·9	41·4
Ilfracombe (Reservoir)	377	..	..	60·4	45·0
Marwood	400	..	..	59·7	..
East Down	399	..	44·3	..	..
Arlington	612	47·9	46·0	67·4	51·2
Stoke Rivers	767	..	..	..	50·4
Parracombe	795	41·9	39·5	68·7	50·0
Martinhoe	808	38·5	36·2	61·4	44·5
Challacombe	925	52·3	55·5	79·7	64·5
Westward Ho	60	29·0	29·3	42·7	29·8
Northam	67	32·3	..	40·6	31·4
Instow	100	27·8	27·5	41·6	30·7
Simonsbath	1,098	63·7	..	86·6	..

East Down.—Except at its S.W. corner, this whole parish is well sheltered from S.W., W., and N.W. winds. At this corner three farms are exposed to S.W. The village is on Morte slates, which constitute most of the soil of the parish. There is a little sandstone.

Kentisbury is probably sheltered from S.W. and W., but partly, at least, exposed to N.W. It is on Ilfracombe beds.

Parracombe seems well sheltered from S.W. and W., but is fully open to the N.W. It is on Hangman grits and Ilfracombe beds—the village on the latter.

Martinhoe is sheltered from S.W. and W., but open to N.W.; the village high and exposed. The northern part, with the village, is on Hangman grits, the southern on Ilfracombe beds.

Combemartin.—A large village, in a combe running up from the Bristol Channel towards the south-east, and so well sheltered from S.W. and W., but peculiarly open to the N.W. The village is on Ilfracombe beds, the soil of the parish being partly Ilfracombe beds, partly Hangman grits.

Countisbury.—There is some difficulty in assessing the shelter and exposure of this parish. The village, at least, is exposed to S.W., W., and N.W. Foreland grits and sandstones form the soil.

Bratton Fleming.—The east of the parish is well sheltered from S.W., W., and N.W., but the village itself is well exposed to S.W. and W. Some farms are exposed, some sheltered. The village stands on Pickwell Down sandstone, which forms the southern part of the parish, the northern being composed of Morte slates. Some igneous rock occurs in patches.

Georgeham.—The village and most of the houses lie low, exposed to W., partly to S.W., but sheltered from N.W. The parish is on Baggy beds, Pickwell Down sandstone, and Pilton beds, the village on Baggy beds.

Shirwell.—The village itself is sheltered from S.W., W., and N.W., but the parish is a large one and, except the village, is generally exposed to S.W. and W., especially Shirwell Cross, which is also exposed to N.W. The village is on Baggy beds, the parish on these, Pilton beds, and Pickwell Down sandstone.

Morthoe.—Exposed to S.W., W., and N.W. The village is on Morte slates, the rest of the parish on Morte slates (the main part) and Pickwell Down sandstone.

Braunton.—A large village lying fairly low. Exposed to S.W. and W., but sheltered from N.W. The soil consists of Pilton beds.

Heanton Punchardon.—Low-lying, swept by S.W. and W. Sheltered from N.W. On Pilton slates.

Ashford.—Exposed to S.W. and W. Sheltered from N.W. Lies rather low. On Pilton slates.

Goodleigh.—Exposed to S.W. and W. On Pilton slates.

Stoke Rivers.—Exposed to S.W., W., and N.W. The village is on the boundary between Baggy beds and Pilton slates. The parish is on Baggy beds, Pickwell Down sandstone, and Pilton slates.

Loxhore.—The village lies very high and is very exposed to S.W., W., and N.W. Some other houses are very exposed, but some are sheltered. The village is on Pickwell Down sandstone. The north of the parish is on Morte slates, the south on the sand stone. A few patches of igneous rock exist.

The Influence of Rainy Winds

Reviewing, as far as is possible with these data, the soil of the parishes, and taking into account their populations, it may be fairly said that the villages classed in the accompanying tables as "II. Exposed to N.W. only," are on the most generally impervious soil, whilst those classed as "III. Exposed to S.W. and W., some also to N.W.," are on the most generally pervious soil.

Again, on examining the rainfall of the north of Devon, it is seen that, on the whole, the heaviest rainfall is on the parishes in Class I, that is, "Sheltered from S.W., W., and N.W.," these being mostly very high-lying parishes, and that the lowest rainfall is on the parishes in Class III, which include many large low-lying villages near the western coast or the banks of the estuary. It, therefore, cannot be alleged that dampness of subsoil accounts for the figures in the following tables. The factor of high rainfall on relatively impervious soil may, however, account for the relatively great mortality in Class II, Table XLVI, during the wetter years.

TABLE

Female Deaths from Phthisis over five Years of Age in Twenty-three Parishes of
Showing the Relation of Phthisis Mortality

Name of parish.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	1867.	1868.	1869.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.
I. Sheltered from S.W., W., and N.W.:																								
Bittadon . . .	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Brendon . . .	..	1	1	..	..	1	..	..	..	..	1	..	..	..	..	..	..	..	1	..	..	..	..	..
Highbray . .	..	2	1	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..
Challacombe . .	..	..	..	..	..	..	1	..	..	..	..	1	1	..	..	..	..	..	..	1	1	..	..	..
Trentishoe . .	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..
Berrynarbor . .	2	..	..	1	..	..	..	..	1	..	1	..	1	1	..	1	1	..	..	..	..	1	..	..
Arlington . .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	2	..	..	..
East Down . .	..	2	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	2
Yearly totals . .	3	5	2	2	1	1	1	1	2	..	2	1	2	1	..	1	1	..	3	3	4	1	..	2
II. Exposed to N.W. only:																								
Kentisbury . .	..	..	..	..	..	..	1	1	..	1	..	..	..	1	..	..	..	1	1	..	..	3	1	..
Parracombe . .	..	1	..	..	1	..	1	..	1	1	..	..	..	..	..	..	..	1	..	..	..	..	..	..
Martinhoe . .	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1
Combe Martin .	4	2	2	1	3	1	1	1	..	1	2	2	3	1	1	1	1	4	5	2	1	..	1	1
Yearly totals . .	4	3	2	2	4	1	3	2	1	3	2	2	3	2	1	1	1	6	6	2	1	4	2	2
III. Exposed to W. and S.W., some also to N.W.:																								
Countisbury . .	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	1	..	..	..	..	..	..
Bratton Fleming .	..	..	1	..	..	1	..	..	..	..	1	1	..	1	..	1	..	..	..	..	..	..	..	2
Georgeham . .	1	1	..	2	2	1	2	1	..	..	..	1	2	1	..	1	1	..	2	1	..	..	..	..
Sherwell . . .	..	..	..	..	3	..	1	1	..	..	2	..	1	..	..	1	..	..	1	1	..	..	..	1
Morthoe . . .	..	..	..	..	..	1	..	1	..	..	1	1	1	..	..	..	..	..	..	..	..	..	..	..
Braunton. . .	3	5	..	2	1	1	1	4	..	1	2	3	..	..	3	3	1	1	1	4	2	4	3	..
Heanton Punchardon	1	..	..	..	1	..	2	..	..	1	..	2	..	..	1	1	..	1	..	..	..	..	1	1
Ashford . . .	..	..	..	..	..	1	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..
Goodleigh . .	..	..	..	1	..	1	..	1	..	..	..	..	..	1	..	1	..	..	1	..	..	..	..	..
Stoke Rivers . .	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	1
Loxhore . . .	..	1	..	..	1	1	1	1	..	..	2	..	..	2	1	..	..	2	..	..	..	1	..	1
Yearly totals . .	5	7	1	5	8	7	7	9	..	3	9	9	5	5	5	8	2	5	5	6	2	5	4	6

XLV

Barnstaple Rural District, Exmoor Portion, during the Forty-five Years, 1860–1904, to Exposure to S.W., W., and N.W. Winds

1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	45 Years Totals.	Female Population. 1851.	1901.	Mean.	Death-rate per 1,000 per annum
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	30	30	30	
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	120	129	124	
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	7	151	99	125	
1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6	146	105	125	
..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	60	32	46	
..	1	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	13	436	316	376	
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	6	99	109	104	
..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	8	219	154	186	
1	4	1	..	1	..	..	..	..	..	..	..	..	..	..	..	1	..	..	1	2	50	..	..	1,116	0·99
..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	11	211	161	186	
1	..	..	..	1	..	..	..	1	..	..	..	..	..	..	..	..	1	..	..	..	10	235	153	194	
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	94	95	94	
3	..	1	2	1	..	..	1	..	..	..	..	1	..	..	..	..	1	..	..	1	53	756	815	785	
4	..	1	2	2	..	..	2	1	..	..	..	1	..	..	..	..	2	..	..	1	76	..	..	1,259	1·33
1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	4	88	155	121	
..	..	1	..	1	1	..	..	..	1	2	..	..	1	..	..	1	..	..	..	..	16	361	263	312	
..	..	..	..	..	..	1	..	..	1	..	1	..	..	..	1	1	..	..	..	1	25	499	358	428	
..	1	2	1	..	1	..	..	..	..	..	..	..	..	1	..	1	..	..	..	1	20	363	165	264	
1	..	..	..	..	..	..	..	..	..	..	1	..	..	1	..	..	..	1	1	..	10	184	440	312	
4	2	4	3	1	2	1	2	2	1	..	1	3	1	1	1	..	..	1	3	1	79	1,231	1,132	1,181	
..	..	..	..	..	..	..	..	..	1	..	1	..	1	..	..	..	1	..	..	..	16	288	205	246	
1	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	89	88	88	
..	..	1	..	..	1	..	1	..	..	..	..	..	..	1	..	1	..	..	..	..	11	144	129	136	
1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3	130	94	112	
1	..	1	..	..	..	..	..	..	..	..	..	..	..	1	..	1	1	..	..	..	19	161	110	135	
9	3	9	4	3	5	2	3	2	4	2	4	3	3	5	3	5	2	2	4	3	208	..	..	3,335	1·38

From a review of the occupations of those dying of phthisis during the forty-five years, so far as these are stated, it cannot be said that specially occupational phthisis has to be taken into account. Thus 177 were "married," 24 were domestic servants, 11 "of no occupation," 8 dressmakers, 5 farm servants, 2 drapers' assistants, 2 carriers, 1 governess, 1 milliner, the rest being given as "single" or "widows."

Table XLV shows that over a period of forty-five years in an average population of 5,710 females, with a total of 334 deaths from phthisis, the phthisis mortality in the exposed

TABLE XLVI

Female Phthisis Death-Rates from 1860 *to* 1904, *as in Table XLV, Arranged in Quinquennial Periods*

Period.	Barnstaple. Total rainfall five years.	I.—Sheltered from S.W., W., and N.W.	II.—Exposed only to N.W.	III.—Exposed to S.W. and W. Some to N.W.	Population according to census of—	Sheltered.	Exposed.
1860–1864	197·67	2·1	2·5	1·5	Mean of 1851 and 1871	1,194	3,288
1865–1869	201·38	0·8	1·6	1·7	1871	1,127	3,038
1870–1874	206·01	1·0	1·6	2·1	1871		
1875–1879	218·25	1·5	2·8	1·8	1881	1,039	2,888
1880–1884	217·00	1·5	2·2	1·8	1881		
1885–1889	177·32	1·1	0·8	1·6	1891	1,071	3,038
1890–1894	158·24	0·0	0·5	0·8	1891		
1895–1899	172·80	0·0	0·1	1·2	1901	974	3,139
1900–1904	187·03	0·7	0·4	1·0	1901		

parishes was greater than in the sheltered parishes; and Table XLVI shows that this greater mortality can be traced in every quinquennial period of these forty-five years except the first. This table also shows that in the wetter years the difference grew less, possibly because of the conflicting influence of soil. Soil influence also possibly caused the remarkable increase in death-rate in Class II, during the wetter years.

Table XLVII shows that, in the twenty years during which diagnosis was probably more exact, the contrast between the mortalities of the exposed and sheltered populations became much more marked. This may possibly also

TABLE XLVII

Female Deaths from Phthisis over Five Years of Age in the Same Area during the Twenty Years, 1885–1904

Name of parish.	Total deaths, twenty years, 1885–1904.	Female Population.			Death-rate per 1,000 per annum.
		1891.	1901.	Mean.	
I. Sheltered from S.W., W., and N.W.:					
Bittadon	0	23	30	27	
Brendon	0	139	129	134	
Highbray	1	109	99	104	
Challacombe	0	113	105	109	
Trentishoe	2	45	32	38	
Berrynarbor	3	340	316	328	
Arlington	2	127	109	118	
East Down	2	175	154	164	
Totals	10	..	..	1,022	0·97
II. Exposed to N.W. only:					
Kentisbury	1	195	161	178	
Parracombe	3	151	153	152	
Martinhoe	0	84	95	90	
Combemartin	8	731	815	773	
Totals	12	..	..	1,193	1·00
III. Exposed to W. and S.W., some also to N.W.:					
Countisbury	1	125	155	140	
Bratton Fleming	8	247	263	255	
Georgeham	6	390	358	374	
Shirwell	8	179	165	172	
Morthoe	4	346	440	393	
Braunton	30	1,125	1,132	1,128	
Heanton Punchardon	4	224	205	215	
Ashford	1	87	88	87	
Goodleigh	5	119	129	124	
Stoke Rivers	0	96	94	95	
Loxhore	4	100	110	105	
Totals	71	..	..	3,088	2·29

TABLE XLVIII

Female Deaths from Phthisis over Five Years of Age in the Same Area during the Ten Years, 1890–1899

Name of parish.	Total deaths, ten years, 1890–99.	Female Population.			Death-rate per 1,000 per annum.
		1891.	1901.	Mean.	
I. Sheltered from S.W., W., and N.W.:					
Bittadon	0	23	30	27	
Brendon	0	139	126	134	
Highbray	0	109	99	104	
Challacombe	0	113	105	109	
Trentishoe	0	45	32	38	
Berrynarbor	0	340	316	328	
Arlington	0	127	109	118	
East Down	0	175	154	164	
Totals	0	..	..	1,022	0
II. Exposed to N.W. only:					
Kentisbury	1	195	161	178	
Parracombe	2	151	153	152	
Martinhoe	0	84	95	90	
Combemartin	2	731	815	773	
Totals	4	..	..	1,193	0·33
III. Exposed to W. and S.W., some also to N.W.:					
Countisbury	1	125	155	140	
Bratton Fleming	4	247	263	255	
Georgeham	4	390	358	374	
Shirwell	1	179	165	172	
Morthoe	2	346	440	393	
Braunton	13	1,125	1,132	1,128	
Heanton Punchardon	3	224	205	215	
Ashford	0	87	88	87	
Goodleigh	2	119	129	124	
Stoke Rivers	0	93	94	95	
Loxhore	1	100	110	105	
Totals	31	..	..	3,088	1·00

be due in part to the removal of some disturbing influence, such as different conditions of life in different parishes, since it is coincident with the general lowering of phthisis mortality, which is generally attributed in England partly to the introduction of better conditions amongst the poorer classes.

Table XLVIII shows that during the ten years in which the problem was simplified by the especially diminished frequency of the north-west wind, and by a lower rainfall not likely to produce a very damp soil, the contrast became exceedingly remarkable.

See also Maps 13 and 14 (Plate V).

To further examine these relations of rain, wind, and phthisis, the accompanying charts have been prepared (facing p. 78).

TABLE XLIX

Rainfall and Phthisis

Name of parish.	Female. phthisis death-rate, 1885–1904.	Annual rainfall (average, 1901–4).
Morthoe (Woolacombe) .	0·5	29·6 in.
Arlington (Court) . . .	0·8	53·1 in.
Parracombe	0·9	50·0 in.
Martinhoe	0·0	45·0 in.
Challacombe . . .	0·0	63·0 in.

Chart I shows how remarkably the curves of rainfall (at Barnstaple) and phthisis mortality (all parishes included) resemble each other. The straight transverse lines indicate, in the rain chart, periods of greater or less rainfall, and the corresponding lines in the phthisis chart show the corresponding average effects on mortality. The general trend of the phthisis mortality is downwards, but the very wet period (*a b*) checked it, the very dry period (*c d*) accelerated it, and the renewal of wet (*c d*) slightly reversed it.

This chart also shows a correspondence between the curve of rainfall and the curve of mortality in the sheltered parishes, which is perhaps an indirect effect through soil.

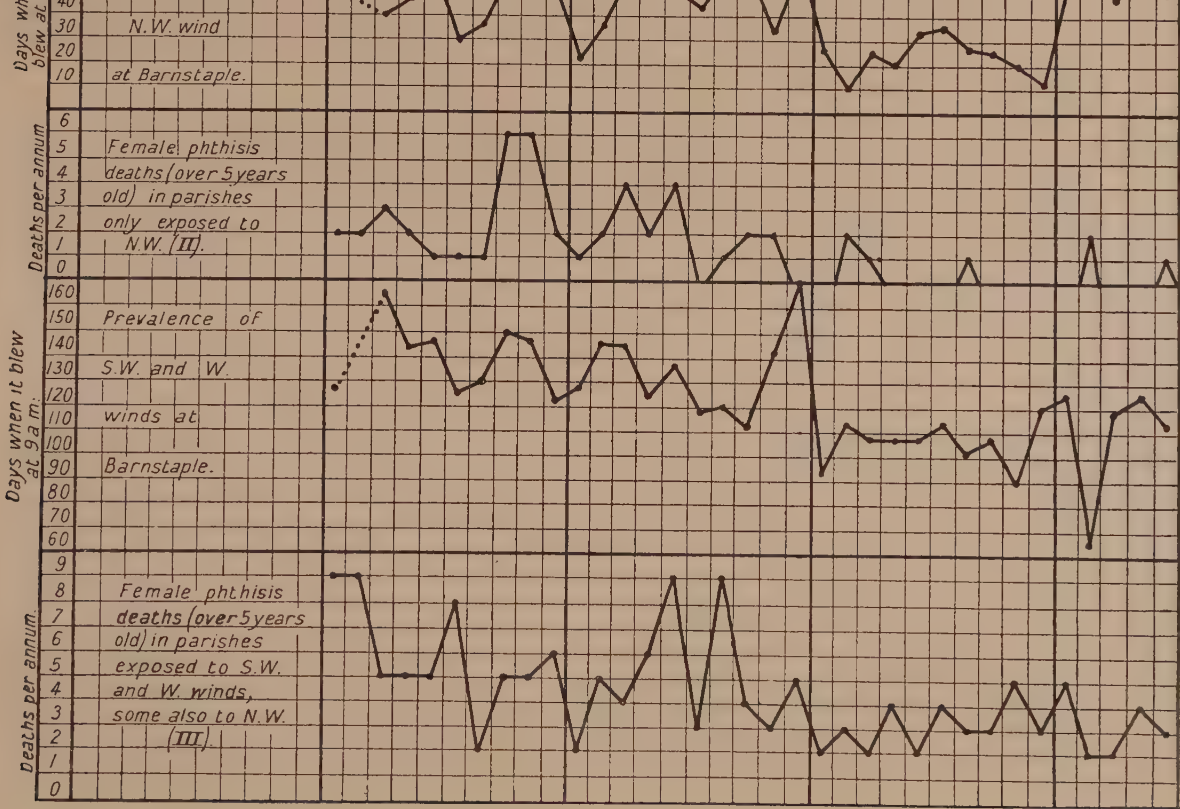
Table XLIX, however, indicates (what has been abundantly proved elsewhere) that rainfall does not, *by itself*,

perceptibly increase phthisis mortality, and, from what has already been said about soil, its influence on the whole distribution of phthisis mortality in these parishes cannot be explained simply as an indirect effect through soil. The results here given can only be reasonably explained as due to the combined effects of wind and rain.

In confirmation of this conclusion, Chart II indicates a rough resemblance between the sharply interrupted curve of N.W. wind frequency, and the also rather sharply interrupted curve of mortality in the population exposed to N.W., and between the relatively steady sweep of the curve of S.W. and W. wind frequency and the similarly steady sweep of the mortality curve of the population exposed to these winds.

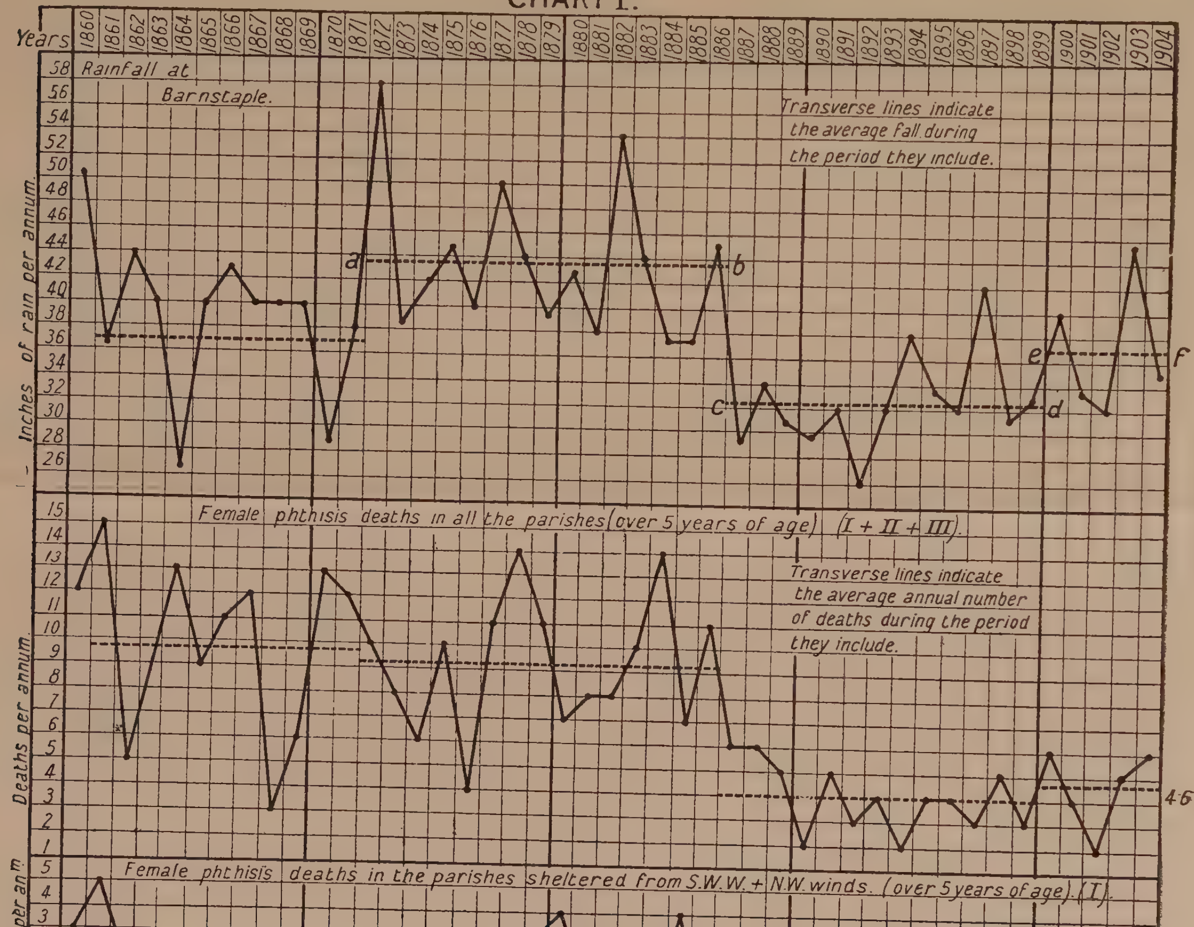
Without insisting, however, on the points illustrated in Chart II, it is clear that these figures bear out the experience of the investigations described in the preceding chapters, that *the death-rate from phthisis of populations exposed to strong prevalent rainy winds is greater than that of populations sheltered from them.*

Dr. Harper and I were greatly aided in our work on these twenty-three parishes by Mr. T. Wainwright, of the North Devon Athenæum, who took immense trouble in preparing for us the necessary meteorological tables, and by Mr. J. G. Hamling of Barnstaple, who, as a geologist specially acquainted with the district, gave us invaluable information.



To face page 78]

CHART I.


Years
1860
1861
1862
1863
1864
1865
1866
1867
1868
1869
1870
1871
1872
1873
1874
1875
1876
1877
1878
1879
1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
Inches of rain per annum.
58
56
54
52
50
48
46
44
42
40
38
36
34
32
30
28
26
Rainfall at Barnstaple.
Transverse lines indicate the average fall during the period they include.
a
b
c
d
e
f
Deaths per annum.
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
Female phthisis deaths in all the parishes (over 5 years of age) (I + II + III).
Transverse lines indicate the average annual number of deaths during the period they include.
4·6
per anm.
5
4
3
Female phthisis deaths in the parishes sheltered from S.W.W. + N.W. winds. (over 5 years of age). (I).

CHAPTER VI

THE INFLUENCE OF PREVALENT STRONG RAIN-BEARING WINDS ON THE PREVALENCE OF PHTHISIS IN VARIOUS PARTS OF THE WORLD

THE influence shown to exist in Devonshire can scarcely be supposed to be peculiar to a single English county; indeed, if a fallacy is to be found in the work dealt with in the foregoing chapters, the best way to look for it will be to seek for definite contradictions in its application to other parts of the world—wherever the necessary information for such an inquiry is obtainable. The object of the present chapter is to show that, in all the countries which I have been able to sufficiently investigate, the same law holds good which holds good in Devonshire.

REGIONS SEPARATELY CONSIDERED ACCORDING TO THE PREVALENCE OF RAINY WINDS

Since great differences exist in the conditions of wind and rain in different belts of latitude, the following regions will be separately considered: A, the northern region of westerly winds—N. of 30° N.; B, the southern region of westerly winds—S. of 30° S.; C, the region of the north-east trade-winds; D, the region of the south-east trade winds; E, the so-called equatorial calm belt; F, the so-called calm belt of Cancer; and G, the so-called calm belt of Capricorn. The Faröes, the Falklands, and Iceland will be considered separately last.

(A) NORTHERN REGION OF WESTERLY WINDS

England.—The prevailing rainy winds are south-westerly, westerly, and north-westerly. Davidson's account of the

phthisis distribution may be summarised thus (see Table L).[1] For the ten years 1871 to 1880, the region of maximum prevalence of phthisis stretched along the western side of the country from Cumberland to Cornwall, extending into Northumberland, whilst the minimum prevalence was found in the counties of Rutland, Worcester, Hereford, Stafford, and Shropshire. The low death-rates of these latter five counties could not be explained on the ground of sparseness

TABLE L.

Average Death-rates per 1,000 *from Phthisis in the Counties of England for the Ten Years* 1871–80, *arranged in Ascending Order.*

Rutlandshire	1·42	Huntingdonshire	1·93
Worcestershire	1·48	Durham	1·93
Herefordshire	1·52	Norfolk	1·94
Staffordshire	1·60	Warwickshire	1·95
Shropshire	1·64	Nottinghamshire	1·96
Somersetshire	1·65	East Riding	1·97
Buckinghamshire	1·69	Cambridgeshire	1·99
Lincolnshire	1·69	Cheshire	2·01
North Riding	1·69	Suffolk	2·02
Dorsetshire	1·72	Westmorland	2·03
Wiltshire	1·74	Sussex	2·05
Hertfordshire	1·75	Devonshire	2·07
Leicestershire	1·77	Bedfordshire	2·12
Middlesex (extra met.)	1·78	Cornwall	2·20
Monmouthshire	1·79	Hampshire	2·20
Gloucestershire	1·81	Cumberland	2·20
Kent (extra met.)	1·83	West Riding	2·26
Essex	1·83	Northumberland	2·27
Northamptonshire	1·86	Lancashire	2·47
Oxfordshire	1·88	London	2·51
Derbyshire	1·90	South Wales	2·54
Surrey (extra met.)	1·91	North Wales	2·57
Berkshire	1·92		

of population, or of agricultural occupation; in Rutland, where phthisis was least prevalent, the acreage per person was the same as in North Wales, where phthisis was most prevalent; in Staffordshire, in spite of its potteries, the mortality was less than in Bedfordshire, which was purely agricultural. In Cornwall, tin-mining, in Lancashire and the West Riding, cotton and woollen manufacturing, and in North Wales, slate, copper, and lead-mining, doubtless increased the mortality from the disease, but in Wales generally injurious industries did not account for its high death-rates

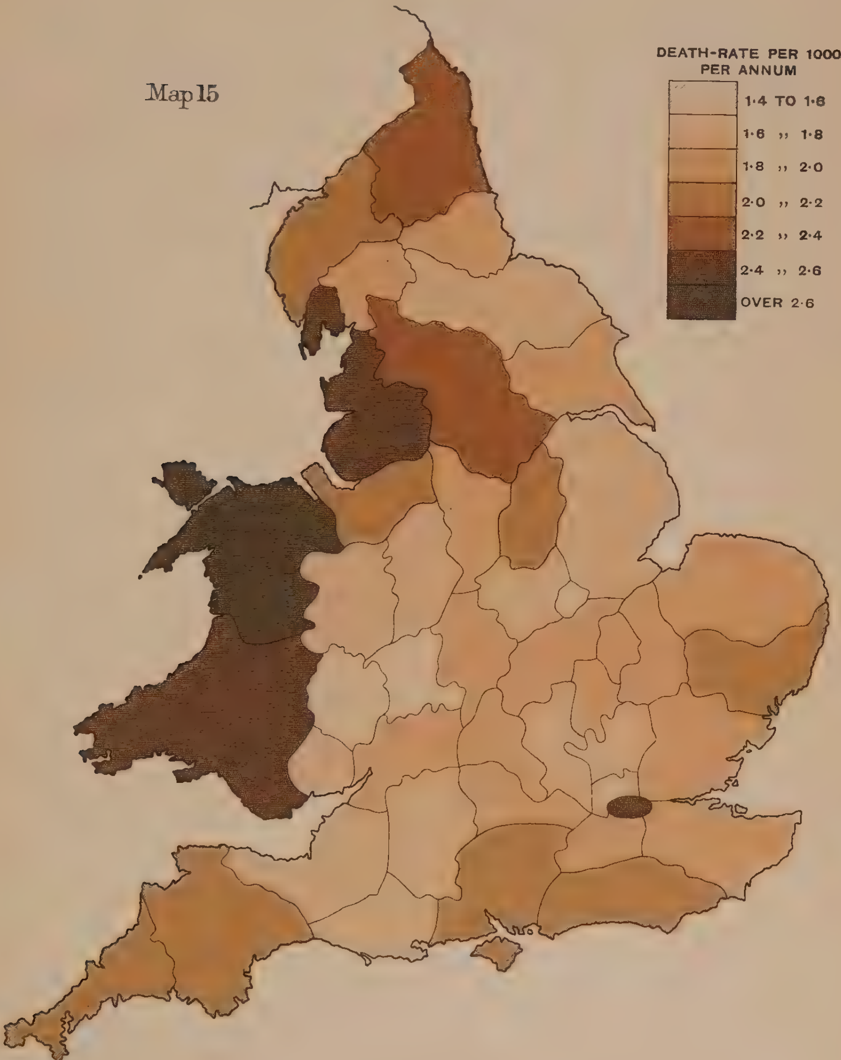
[1] Davidson: "Geographical Pathology," vol. i., pp. 126-28.

ENGLAND AND WALES

Phthisis Death-rates per 1000 in the Counties

Averages of the three decades, 1861-70, 1871-80, and 1881-90

Map 15



Constructed from the figures given in the Supplement to the 55th Annual Report of the Registrar-General. Part I. Table Y. P. LVIII.

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since these were nearly as great in districts where there were no injurious occupations. Davidson thought that soil largely determined the differences in the death-rates of the agricultural counties. But he summed up thus: "It . . . appears, that no complete explanation can be given of the geographical

TABLE LI

Average Death-rates per 1,000 from Phthisis in the Registration Districts of Wales, 1881–90, Exposed and Sheltered as regards Westerly Winds.

Exposed.		Exposure to	Sheltered.	
Gower	1·68	W., S.W.	Crickhowell	1·33
Conway	1·69	W.	Pontypridd	1·36
Bridgend	1·74	N.W.	Forden	1·42
Holywell	1·78	N.W.	Wrexham	1·46
Pembroke	1·93	N.W., W., S.W.	Hay	1·47
Ruthin	1·94	N.W.	Knighton	1·65
Lampeter	1·96	N.W., W., S.W.	Llanfyllin	1·82
Dolgelly	2·01	W., S.W.	Corwen	1·86
Llanelly	2·04	S.W.	Swansea	1·86
Neath	2·06	S.W.	Cardiff	1·87
Pwllheli	2·06	N.W., W., S.W.	Bala	1·88
St. Asaph	2·09	N.W.	Brecknock	1·95
Haverfordwest	2·14	N.W., W., S.W.	Newtown	2·04
Llanrwst	2·22	N.W.	Merthyr Tydvil	2·05
Holyhead	2·24	N.W., W., S.W.	Builth	2·10
Anglesey	2·32	N.W., W., S.W. (?)	Rhayader	2·16
Llandovery	2·39	N.W.		
Festiniog	2·51	S.W.		
Bangor	2·52	N.W., W., S.W.		
Pontardawe	2·57	W., S.W.		
Aberayron	2·67	N.W., W.		
Machynlleth	2·68	W., S.W.		
Cardigan	2·69	N.W., W.		
Llandilofawr	2·74	S.W.		
Carmarthen	2·76	S.W.		
Tregaron	2·80	W., S.W.		
Narberth	2·90	N.W., W., S.W.		
Aberystwith	2·90	N.W., W.		
Newcastle-Emlyn	2·92	N.W., W., S.W.		
Carnarvon	2·96	N.W., W., S.W.		
Average	2·33	..	Average	1·76

distribution of phthisis in England. We have here to recognise the existence of a zone similar to that which is observed in the Rhine Provinces of Germany, and at certain altitudes in Switzerland in which phthisis, for reasons not yet understood, attains a high degree of prevalence." Now, if we

exclude Northumberland, the high phthisis death-rate of which is doubtless due largely to its industries and its crowded towns, the distribution of phthisis in England, from 1871 to 1880, was very much what it should have been if exposure to rainy wind is taken into consideration. The western counties are the most exposed and had the highest death-rate. Rutland, which is sheltered, Worcester, Hereford, Stafford, and Shropshire, which are perhaps the most sheltered counties from all westerly winds, had the lowest death-rate. This distribution of phthisis is well seen on an inspection of the averages of the phthisis death-rates in three successive decennial periods—*viz.* 1861–70, 1871–80, and 1881–90 (see Map 15). As the high death-rate in Wales might be thought to be due to race, Table LI is appended, showing that within Wales itself the death-rate is heavier in the districts exposed to westerly winds.

Scotland.—Here, again, the prevalent rainy winds are south-westerly, westerly, and north-westerly. If the table of death-rates from phthisis in the Scotch counties for the ten years from 1881 to 1890 be examined (see Table LII), it will be seen that the two lowest death-rates are in Kinross and Nairn, both well sheltered from the rainy winds; that, except

TABLE LII

Average Death-rates per 1,000 *from Phthisis in the Counties of Scotland for the Ten Years* 1881–90, *arranged in Ascending Order.*

Kinross	1·0	Perth	1·7
Nairn	1·1	Roxburgh	1·7
Inverness	1·2	Shetland	1·8
Ross and Cromarty	1·3	Elgin	1·8
Banff	1·3	Dumbarton	1·9
Kincardine	1·3	Argyll	1·9
Berwick	1·3	Edinburgh	1·9
Orkney	1·4	Wigtown	1·9
Caithness	1·4	Ayr	2·0
Aberdeen	1·4	Forfar	2·1
Haddington	1·4	Dumfries	2·1
Peebles	1·4	Kirkcudbright	2·1
Sutherland	1·5	Bute	2·2
Linlithgow	1·5	Selkirk	2·2
Fife	1·6	Lanark	2·4
Clackmannan	1·6	Renfrew	2·5
Stirling	1·6		

The figures are taken from the Registrar-General's returns.

Elgin, Forfar, and Edinburgh (of which the first is open to the north-west, whilst the other two contain very populous towns), the eastern counties have relatively low death-rates, whilst the western counties, as far north as Argyll, have all relatively high death-rates. North of Argyll on the west, the counties either run across from east to west, or, like Inverness, include great inland areas with marked local shelter, and therefore can scarcely be used for comparison. Of the western counties with high death-rates it must, however, be remembered that Renfrew includes part of Glasgow.

Ireland.—The configuration of the country makes its relative shelters and exposures to the south-westerly, westerly,

TABLE LIII

Average Death-rates per 1,000 from Phthisis in Dublin and the Fifteen Principal Urban Districts of Ireland, of which Records are available from 1893 to 1902, arranged in Ascending Order.

	Mean population.	Average death-rate.		Mean population.	Average death-rate.
Drogheda	12,316	1·6	Londonderry	36,964	2·7
Dundalk	12,762	1·8	Belfast	361,901	2·9
Kilkenny	10,828	2·1	Waterford	23,810	2·9
Newry	12,683	2·2	Lurgan	11,605	3·0
Armagh	7,513	2·2	Limerick	37,653	3·0
Sligo	10,572	2·5	Dublin	364,294	3·2
Wexford	11,356	2·6	Lisburn	11,855	3·3
Galway	13,613	2·6	Cork	75,733	3·8

and north-westerly, the prevalent rainy winds, extremely difficult to assess. The rainfall, too, does not decrease from west to east in the regular way it does in Great Britain.[1] Also the most populous and industrial centres are on or near the eastern coast. Perhaps, in view of the greater ease of comparing their shelters and exposures, a comparison of urban districts may give more definite results than a comparison of wider areas. I have taken ten years' records for sixteen such districts. (See Table LIII). Of the two great populations of Dublin and Belfast, Dublin, most open to the rainy winds, although less industrial than Belfast, has the

[1] See Bartholomew's "Atlas of Meteorology," edited by Dr. A. Buchan, F.R.S., plate xxiii.

higher death-rate. Of the other towns, those with the lowest death-rates, Drogheda, Dundalk, Kilkenny, Newry, and Armagh, are all in the eastern part of the island, and more or less sheltered from the rainy winds. Lurgan and Lisburn, although in the eastern counties, have a high death-rate, but they are by no means sheltered and are great linen manufacturing centres. In spite, therefore, of the peculiar difficulty of an inquiry into the influence of rainy wind on phthisis in Ireland, indications are not wanting that exposure to rainy wind and relatively high phthisis death-rate tend to correspond.

Norway.—The prevalent strong rainy winds of Norway are the south-west, west, and north-west. On the south and south-east coasts the south and south-east winds seem to be also rainy.[1] The greatest mortality from phthisis (see Table LIV)

TABLE LIV

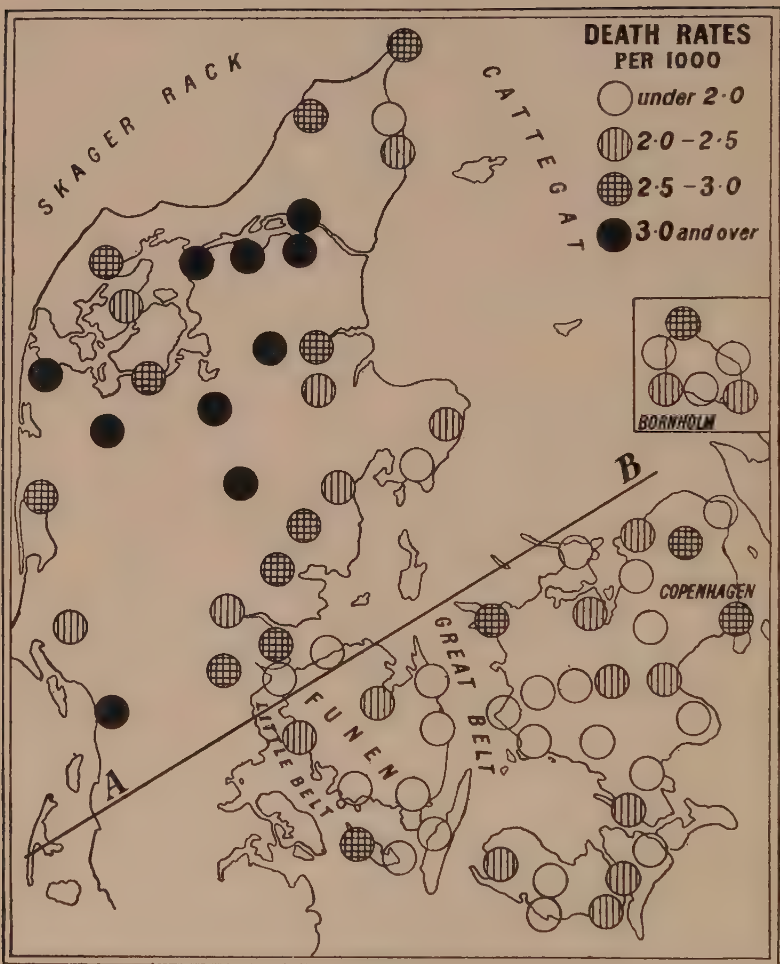
Death-rates per 1,000 from Phthisis in the Counties of Norway.

Name of country.	1898.	1899.	1900.	Average 1898–1900.	1901.
Kristiana	1·5	1·9	1·7	1·7	1·1
North Bergenhus	1·9	1·8	2·4	2·0	1·4
Hedemarken	1·9	2·3	2·4	2·2	1·7
Nordland	2·0	2·5	2·2	2·2	1·3
South Bergenhus	2·3	2·3	2·5	2·4	1·7
Smaalene	2·7	2·6	2·6	2·6	1·9
North Trondhjem	2·9	2·5	2·5	2·6	1·7
Akershus	2·8	2·5	2·6	2·7	1·8
Jarlsberg	2·9	2·9	2·3	2·7	2·1
Buskerud	2·8	2·8	2·7	2·8	2·0
Romsdal	2·8	3·0	2·7	2·8	1·9
Bratsberg	2·8	2·7	3·2	2·9	2·4
Bergen, City	2·6	2·9	3·1	2·9	2·3
Tromsoe	2·9	2·9	2·9	2·9	1·4
Kristiana, City	3·1	3·1	3·0	3·1	1·4
Finmarken	3·2	3·2	3·1	3·1	2·0
Nedenes	3·1	3·4	3·0	3·2	2·4
Stavanger	3·1	3·4	3·2	3·3	2·4
South Trondhjem	3·1	3·7	3·7	3·5	2·2
Lister and Mandal	4·4	4·5	4·5	4·5	2·4

Figures kindly sent me by Dr. M. Holmböe, Director of the Medical Service of Norway.

[1] Hann: "Handbuch der Klimatologie," vol. i. p. 354, and vol. iii. pp. 139–44. Bartholomew's "Atlas of Meteorology," plate xii. Longman's "Gazetter of the World," 1895. Baedeker's "Norway and Sweden," p. 37.

PLATE VII



MAP 16

TUBERCULOSIS DEATH-RATES IN THE TOWNS OF DENMARK, 1890–1899.

is found in the south-western counties, where the fiords and valleys afford ready access to the south-west, south, and south-east winds. Of the only other counties with heavy mortality, South Trondhjem appears to afford exceptionally easy access to the north-west wind, but of Finmarken I have too little information to speak. The counties protected from sea gales, either by the narrowness of their winding fiords or by their inland position, suffer least from the disease.

Sweden.—The position and surface of Sweden make the inquiry in that country difficult, and I have no very recent figures. Davidson says that in 1886 and 1887 phthisis was more fatal in the centre and south than in the north, and was most fatal between 58° and 60° N.[1] This is the region of the

TABLE LV

Death-rates per 1,000 *from Phthisis in Towns of Sweden,* 1886 *and* 1887.

	Number of towns.	Population, 1886.	Death-rate, 1886.	Death-rate, 1887.	Mean.
North of Lat. 62° . .	7	31,050	2·93	2·38	2·65
Between Lat. 62° and 60° .	5	43,150	2·68	2·44	2·56
Between Lat. 60° and 58° .	9	99,509	3·33	3·03	3·18
South of Lat. 58° . .	8	214,798	2·81	2·86	2·84

From Davidson's "Geographical Pathology," vol. i., p. 40.

lakes, and is the part most open to rainy winds from the Atlantic.[2] The figures given by Davidson, however, relate only to towns. (See Table LV.)

Denmark.—The annexed map (Map 16), for which I have to thank the kindness of Dr. Rördam, illustrates the tuberculosis death-rates in the towns of Denmark. A line A B drawn along the north-west coast of Europe, and produced so as to cross Denmark, divides it into a northern area in which the south-west wind is a sea wind, and therefore presumably relatively rainy, and a southern area in which the south-west wind is a land wind, and presumably relatively dry.[3] All

[1] *Op. cit.*, vol. i. p. 40.

[2] See Bartholomew's "Atlas of Meteorology," plates xii. and xxi.

[3] See also "The Climate of Denmark," by Adam Paulsen, "Chicago Meteorological Congress," part iii.

the highest death-rates lie north of this line, and the only low mortalities north of the line are seemingly under shelter of the east coast. Also, as the rainfall lessens from west to east, the tuberculosis mortality in the towns also decreases from west to east.[1]

Germany.—The chief rainy winds of Germany are south-westerly, westerly, and north-westerly. Most rain falls in

TABLE LVI

Average Death-rates per 1,000 *from Phthisis in the Rural Populations of the Provinces of Prussia for the Years* 1875 *to* 1879 (*Schlockow*).

Baltic Provinces.		*North Sea.*	
Gumbinnen	1·84	Hanover	4·44
Königsberg	1·45	Hildesheim	3·21
Dantzig	1·41	Lüneburg	3·39
Marienwerder	1·35	Stade	4·20
Stettin	2·08	Osnabrück	5·22
Köslin	1·60	Aurich	3·79
Stralsund	2·12		
Schleswig	3·18	*Lower Rhine.*	
Warta and Oder.		Cöln	5·34
Posen	2·04	Treves	3·56
Bromberg	1·85	Aix	4·59
Breslau	2·75	Coblenz	4·35
Liegnitz	2·35	Düsseldorf	5·29
Oppeln	2·45	Münster	4·70
Frankfurt	2·25	Minden	4·90
Prussia, Saxony, and the Mark.		Arnsberg	4·51
Potsdam	2·33		
Madgeburg	2·65	*Upper Rhine.*	
Merseburg	2·16	Cassel	3·03
Erfurt	2·70	Wiesbaden	4·08

These figures are taken from Hirsch's "Geographical and Historical Pathology."

June, July, and August, during which the north-west wind becomes relatively common.[2] Schlockow has shown[3] that tuberculosis is much more fatal in the western than in the eastern provinces, the high mortality in the Lower Rhine

[1] See plates xxviii.-xxxi., published with Paulsen's paper.

[2] Hann, *op. cit.*, vol. iii., pp. 154-69. Also M. Alfred Angot's fine maps in his "Régime des Pluies de l'Europe Occidentale."

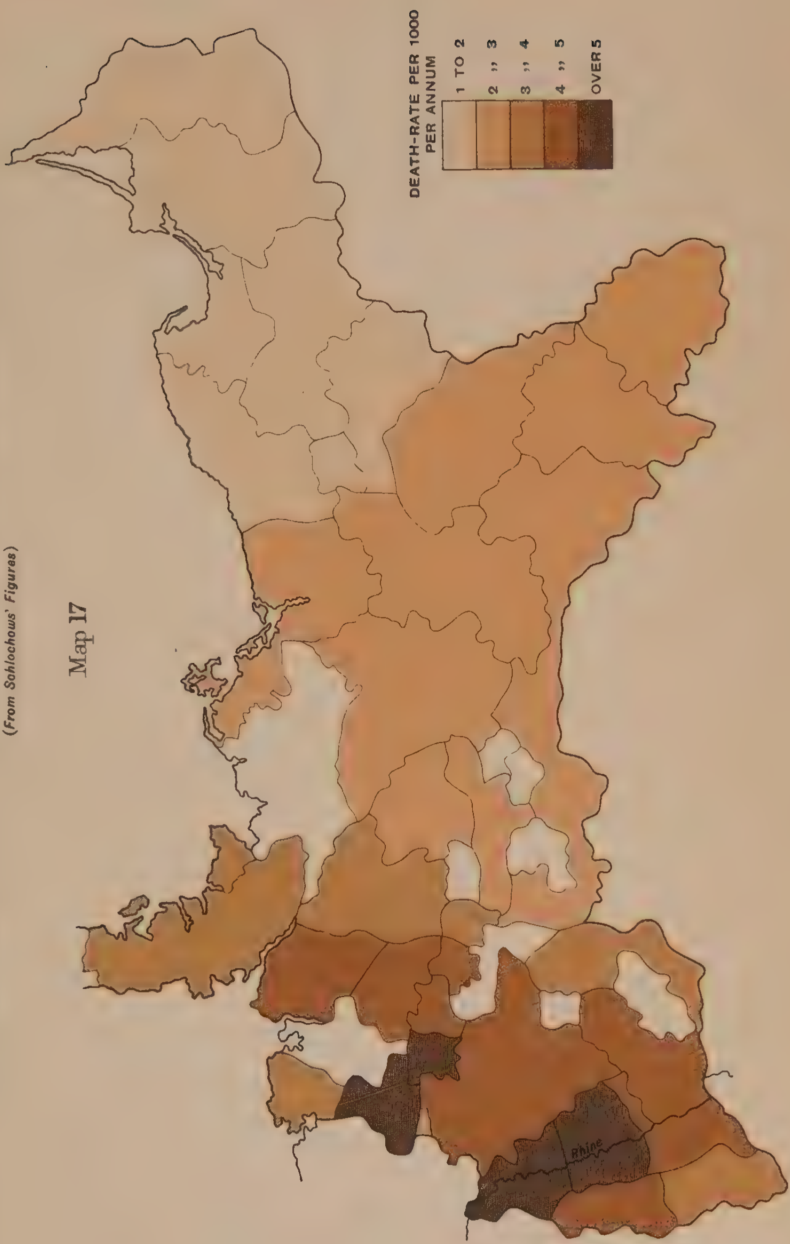
[3] Hirsch: "Handbuch der Historisch-Geographischen Pathologie," vol. iii., p. 179.

PRUSSIA

Phthisis Death-rates in the Rural Populations of the Provinces between 1875 and 1879

(From Schlochows' Figures)

Map 17



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towns being specially remarkable, and Hirsch points out that this cannot be explained as due to hurtful industries, because the smaller rural districts in the western provinces show a very high death-rate (see Map 17). Davidson says:[1] "Whatever may be the explanation, the distribution-area of phthisis in Germany is in a marked degree determined by longitude." Schlockow's figures (see Table LVI) for the rural populations of the Prussian provinces are all the better for the present purpose that they refer to the years 1875 to 1879, before the conflicting influences of growing industries with increasing wages, in some provinces, and of special precautions against phthisis, in the same provinces or in others, came into operation. When these figures are looked at, it becomes instantly apparent that the provinces exposed to the rainy north-west winds from the North Sea suffer most from phthisis.

Switzerland.—The rainy winds of Mid-Europe are the south-westerly, westerly, and north-westerly.[2] Parts of Switzerland must also get rainy south-east winds from the Adriatic.[3] The mountain ramparts of Switzerland shut out these winds except at certain points, and therefore the assessment of shelter and exposure to rain-bearing winds in Switzerland becomes difficult. Moreover, the winds as they sweep over the maze of mountain and valley, must obviously bend and interlace in a confusing manner. Also, since the prevalent wind on the Rigi appears sometimes to be north-west, when that on the loftier Säntis is south-west,[4] it seems likely that the warmer southern currents float over cooler northern currents. Therefore every district requires a specially careful investigation. Thanks to the kindness of Dr. W. R. Huggard, who lent me his valuable maps of the Grisons,[5] I have been able to examine that canton in detail. I have also travelled over much of it. The result, which I have already dealt with in Chapter II., shows almost everywhere that complete exposure to rainy winds corresponds with a

[1] *Op. cit.*, vol. i., p. 87.
[2] Hann, vol. iii., pp. 154–69.
[3] "On the Sirocco," see Hann, *op. cit.*, vol. iii., p. 49.
[4] *Annalen der Schweizerischen Meteorologischen Central-Anstalt*, 1900.
[5] "Topographischer Atlas der Schweiz."

relatively high mortality from tuberculosis. It is not impossible that the curious fact, alluded to by Davidson, that there is a middle altitude belt of higher phthisis mortality in the Swiss Alps may be explained by the presence of considerable populations occupying exposed situations at those levels.

France.—In the report of the French Tuberculosis Commission (1900) Professor Brouardel states that there are three chief centres of tuberculosis in France,[1] *viz.*: (1) Paris and the neighbouring departments, extending through the north-east corner of France; (2) Brittany with Mayenne; and (3) from Doubs through Lyons to Gard. The method by which the figures for the departments have been obtained is, as Professor Brouardel points out, crude,[2] but he evidently considers this broad conclusion correct, nevertheless. The rainy winds of France, west and north-west of the Cevennes, are from the Atlantic, therefore westerly and north-westerly everywhere. In the north-west and north of France south-west winds must be also rainy, but from the south-west departments and the centre of France, Spain and the Pyrenees cut off the rain from this quarter. South and south-east of the Cevennes, according to Hann, belongs climatologically to the Mediterranean countries,[3] and gets rainy winds from the south-south-west, south, and south-east. The higher altitudes of the French Alps, however, must still get rain from westerly Atlantic winds. When these relations of the rainy winds are borne in mind, Professor Brouardel's three centres can, I venture to think, be roughly accounted for. There are, broadly speaking: (1) A belt of high tuberculosis mortality all along the north-west and north coasts of France, reaching a considerable distance inland, and corresponding to a region where probably north-west, west, and south-west are all wet winds; (2) a broad interior region of lower tuberculosis death-rate, over which the south-west winds from Spain must be relatively dry; (3) a region of high death-rate along the valleys of the Rhône and Saône, where rainy winds from the Atlantic and the Mediterranean may be supposed to meet; but (4) a low death-rate in the Alps, the valleys

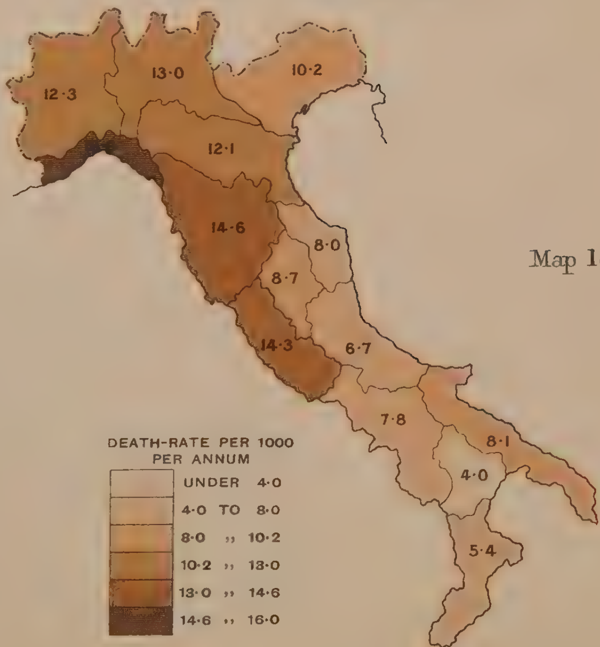
[1] "La Propagation de la Tuberculose," 1900, pp. 7, 8.
[2] "Assez grossier," *loc. cit.*, p. 7.
[3] Hann, *op. cit.*, vol. iii., p. 114.

ITALY

Phthisis Death-rates in the Provinces between 1888 and 1899

Averages of the Ten years, 1888-94 and 1895-99

(From Bulstrode's Milroy Lectures 1903)



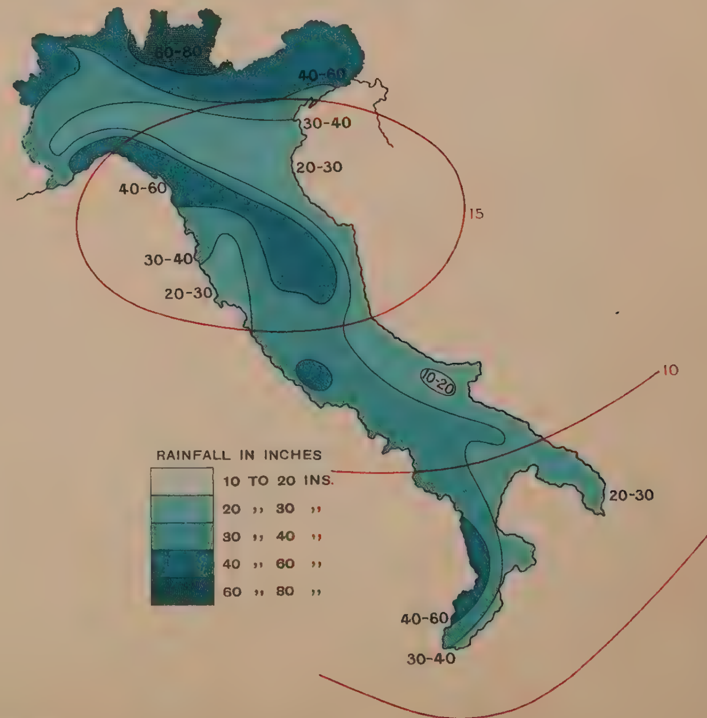
Map 18

ITALY

Annual Rainfall and Storm-frequency

Black Curves and Figures indicate Rainfall Areas
Red Curves and Figures indicate Storm-frequency Areas

(From Bartholomew's Meteorological Atlas)



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of which are protected from all rainy quarters; (5) the Pyrenean valleys have also a low death-rate, in spite of their heavy rainfall, because their direction shelters them also from the west.

Corsica has most phthisis, Dr. Trotter informs me,[1] on its western side, which is the more exposed to rainy winds. It must, however, at the same time be mentioned that the western is the poorer district.

Spain.—The heaviest rainfall in Spain is on its northern and north-western coasts, where the Atlantic gales are fully felt. The least rainfall and least wind are on its south-eastern coast at Malaga and Valencia.[2] According to Dr. Zerolo's figures, quoted by Dr. J. Cleasby Taylor[3] (see Table LVII), the phthisis death-rates in these two regions are as strikingly different as their wind and rain. Barcelona, which appears to get more rainy wind than the districts

TABLE LVII

Average Death-rates per 1,000 *from Phthisis in the Northern and South-eastern Coast Provinces of Spain during Five Years, from Zerolo's "Tuberculoso y Clinatherapeutica," in order of Ascending Phthisis Mortality.*

Altantic Coast, North.			Mediterranean Coast, S.E.		
	Population.	Death-rate.		Population.	Death-rate.
Corunna	602,582	1·70	Almeria	354,619	0·69
Santander	236,993	1·84	Alicante	415,077	0·80
San Sebastian	171,170	2·26	Valencia	688,768	1·10
Bilbao	193,233	2·66	Malaga	509,171	1·11
			Murcia	457,765	1·25

farther south, has a higher death-rate from phthisis than they have.

Italy.—The chief rainy winds appear to be south-westerly, westerly, and north-westerly, and the rainfall is heavier on

[1] Private letter.

[2] Bartholomew's "Atlas of Meteorology," plates xxi. and xxii. Also Hann, *op. cit.*, vol. iii., p. 77. Also Bennett's "Winter and Spring on the Shores of the Mediterranean," p. 555.

[3] "Health Resorts of the Canary Islands," p. 63.

the western side of the peninsula.[1] The south-east seems to be a rainy wind only round the head of the Adriatic.[2] The figures recently given by Dr. H. T. Bulstrode (see Table LVIII) for the distribution of phthisis in the pro-

TABLE LVIII

Average Death-rates per 1,000 *from Phthisis in the Provinces of Italy from* 1888–94 *and* 1897–99, *from Dr. Bulstrode's "Milroy Lectures."*

Provinces West of the Apennines from North to South.		Provinces East of the Apennines from North to South.	
Coast.		Piedmont	1·23
Liguria	1·60	Lombardy	1·30
Tuscany	1·46	Venetia	1·02
Latium	1·43	Emilia	1·21
Campania	·78	The Marches	·80
Calabria	·54	Abruzzi	·67
Inland.		Apulia	·81
Umbria	·87	Basilicata	·40

vinces[3] correspond strikingly with the conditions of wind and rain (see also Map 18).

Northern Africa.—Algiers, exposed to a prevalent north-west rainy wind,[4] has a considerable death-rate in its coast towns.[5] Tunis, sheltered by the extremity of Mount Atlas from north-west winds, is extremely dry[6] and tuberculosis is stated to be less common amongst the French troops there than in any other corps of the French army.[7] The Delta of the Nile, where rainy winds from the north-west and north are common,[8] contrasts markedly with the country above Cairo, in having a considerable death-rate from phthisis.

Persia.—Persia is a very dry country,[9] and the late Sir

[1] Bennett, *op. cit.*, pp. 69 and 355. Hann, *op. cit.*, vol. iii., pp. 88 and 89. Bartholomew's "Atlas of Meteorology," plates xxi. and xxii.

[2] Hann, *loc. cit.*

[3] "Milroy Lectures," 1903. *Lancet*, August 1, 1903, p. 298.

[4] Bennett, *op. cit.*, pp. 521–25. Private letter from Dr. W. Thomson, Mustapha.

[5] Davidson, *op. cit.*, vol. ii., pp. 594, 595.

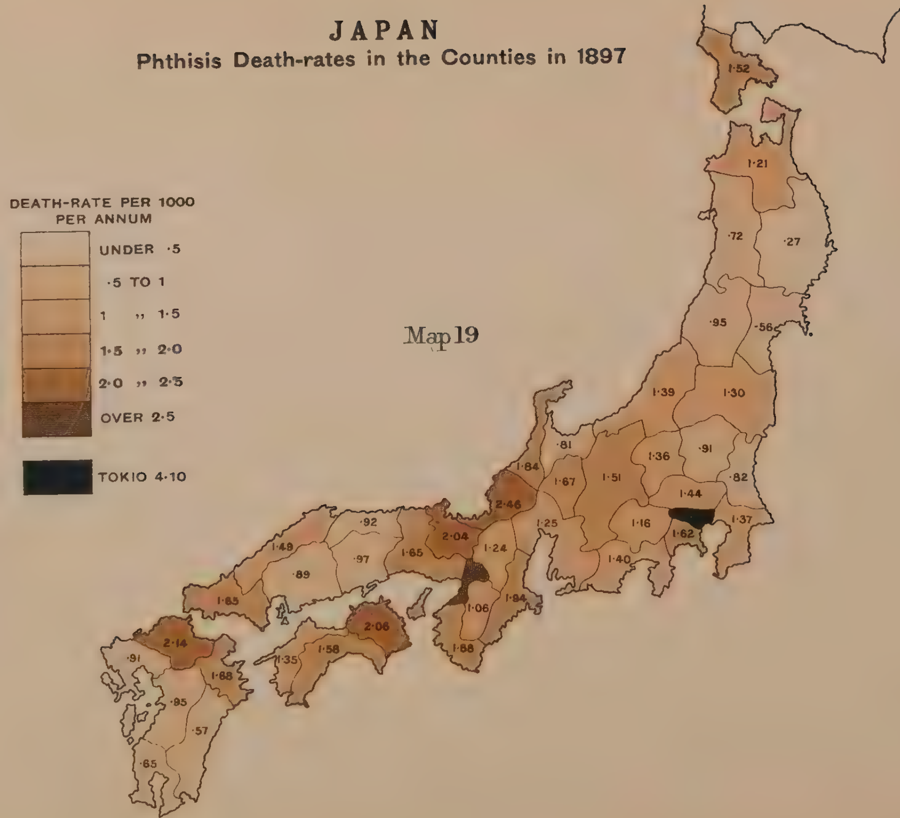
[6] Bartholomew's "Atlas of Meteorology," plates xxi. and xxii.

Clemow, *op. cit.*, p. 459.

[8] Hann, *op. cit.*, vol. iii., pp. 72, 73.

[9] *Ibid.*, p. 111.

JAPAN
Phthisis Death-rates in the Counties in 1897



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Hugh Adcock informed me that phthisis there is "not at all common."[1]

Kashmir.—Kashmir is shut in by great mountains on all sides, and is therefore comparatively windless.[2] Mr. A. Neve tells me that, except in the very crowded and insanitary capital, phthisis is "almost unknown."[3]

Japan.—The distribution of phthisis in Japan is interesting. Dr. W. W. Colborne, of Hakodate, has been so kind as to send me a map of the distribution of phthisis in the counties (Map 19). Before consulting Hann's "Climatology" on the Meteorology of Japan, I tried to discover from the phthisis distribution what is the prevalent strong rainy wind, and decided that the north-west must be the wind in question. On referring to Hann I found that it is so.[4] The north-west wind of winter is in Japan a very violent, constant, and rainy wind. There is, however, another rainy wind—the south-west of summer. This brings a heavy rainfall, but its force is "incomparably" less than that of the winter north-west.

United States of America.—For the whole of the United States I can only obtain the table given by Davidson (see Table LIX).[5] This only deals with one year, and only gives the phthisis death-rate per 1000, deaths from known causes (Map 20). Still, it is clearly worth considering. The greater part of the United States consists of wide plains, swept by westerly, north-westerly, and south-westerly winds (Map 22).[6] On the Pacific side the rain is cut off from the interior by a lofty range parallel to the coast. Within this westerly rampart the land is raised in high valleys and plateaux, broken by great mountain ranges which culminate in the Rockies. Over this elevated region strong winds blow, but they are for the most part dry, the rainfall being small. East of the Rockies the winds across the great plains are

1 Private letter. 2 *Ibid.* 3 *Ibid.*

4 Hann, *op. cit.*, vol. iii., pp. 250–56.

5 Davidson, *op. cit.*, vol. ii., p. 848, taken from the "Report on the Mortality and Vital Statistics of the United States," by John S. Billings, parts 1 and 2. Washington, 1885.

6 Hann, *op. cit.*, vol. iii., pp. 310–17. Also Solly: "Medical Climatology," pp. 185–86.

still relatively dry until the Mississippi valley is approached. There rainy south-west winds become frequent and extend over the Eastern States. On the Atlantic seaboard rainy winds from easterly directions are common and strong. The Appalachian range in the Eastern States must have rainy winds from both east and west. In Florida, according to the Storm Plates in Bartholomew's "Meteorological Atlas," the wind is lighter. Bartholomew's "Atlas" also shows well

TABLE LIX

Showing for the Rural Districts of Regions of the United States the Proportion amongst Females of Deaths from Phthisis in 1,000 *Deaths from Known Causes* (*Billings, quoted by Davidson*).

No.	Grand Groups.	Proportion per 1,000 deaths.
1	North Atlantic Coast region . .	197·2
2	Middle " " " . .	168·5
3	South " " " . .	101·6
4	Gulf Coast region	100·9
5	North-eastern hills and plateaux .	186·1
6	Central Appalachian region . .	136·9
7	Region of Great Northern Lakes .	156·8
8	Interior plateau	166·6
9	Southern Central Appalachian region .	171·0
10	Ohio River belt	195·6
11	Southern Interior plateau . . .	116·5
12	South Mississippi River belt . .	115·7
13	North " " " . .	125·3
14	South-west Central region . . .	84·4
15	Central region plains and plateaux .	180·4
16	Prairie region	122·0
17	Missouri River belt	121·4
18	Region of Western Plains . . .	68·2
19	Heavily timbered region of North-west	139·1
20	Cordilleran region	85·6
21	Pacific region	184·1

the distribution of rainfall in the States.[1] Corresponding to this distribution of rainy wind, the census for 1880 gives the following distribution of phthisis mortality (Table LIX). The Pacific coast has a high death-rate, though it should be remembered that it has not been divided as the Atlantic coast has been in the census, so that it is impossible to say whether the mortality south of San Francisco is different from that farther north ; also it must be borne in mind that

[1] Bartholomew's "Atlas of Meteorology," plate xxi.

UNITED STATES

Phthisis Death-rates among Females in Rural Districts in 1880

(From Davidson's Table)

Death-rates per 1000 of Known Deaths indicated by figures

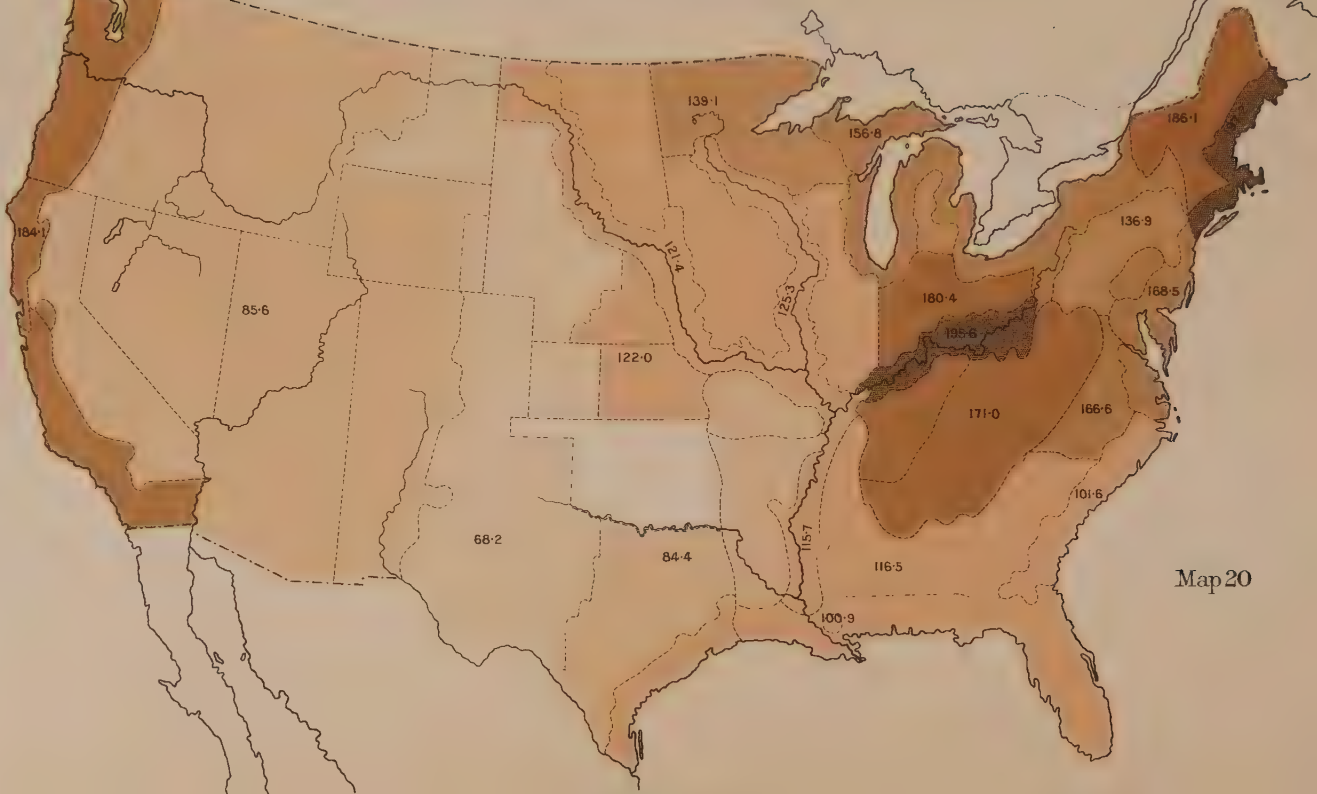

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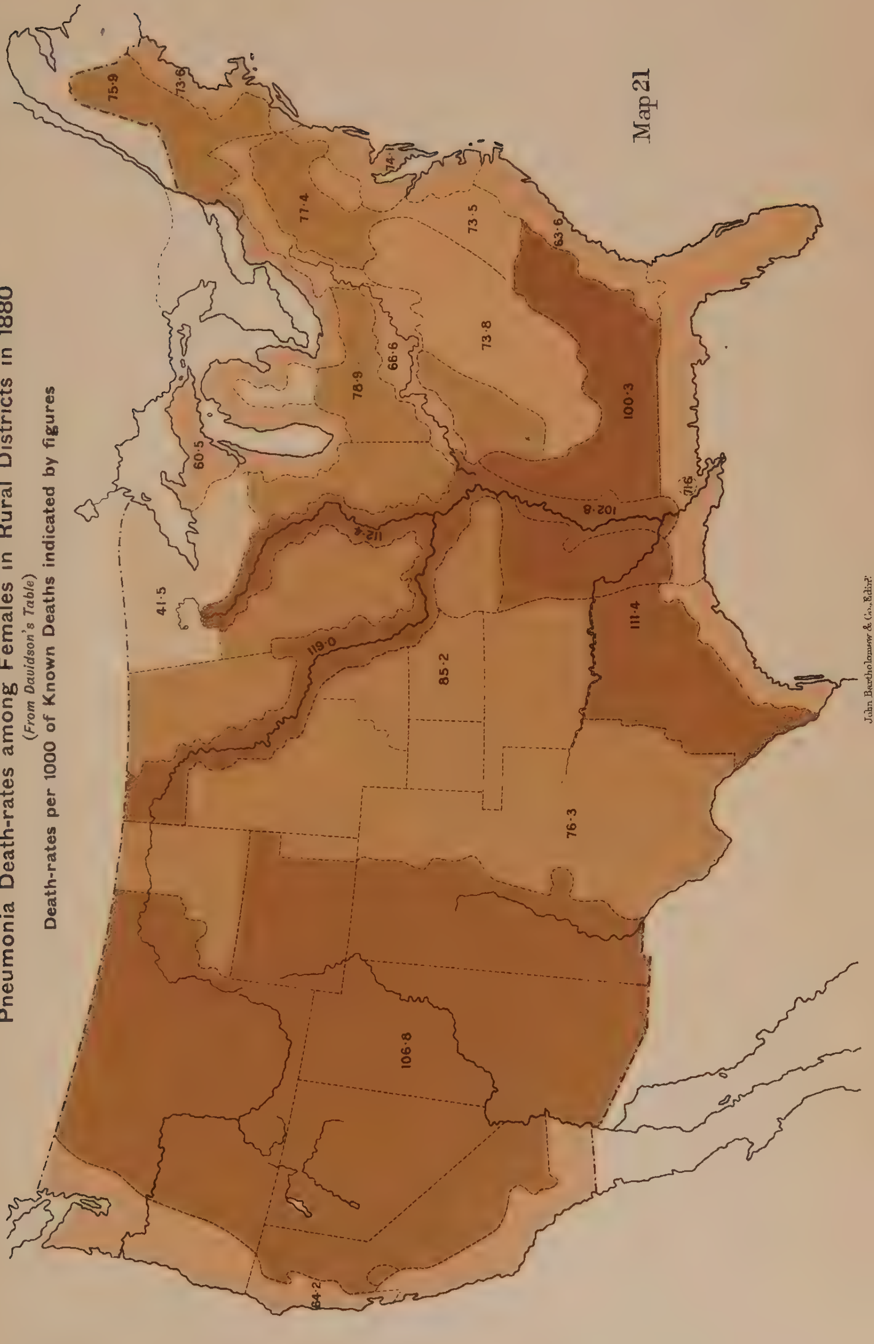
PLATE XI

To face Page 92



UNITED STATES

Pneumonia Death-rates among Females in Rural Districts in 1880

(*From Davidson's Table*)

Death-rates per 1000 of Known Deaths indicated by figures

To face Page 92 behind Plate XI

South California is a much-used phthisis sanatorium, and that therefore many cases are imported. The Cordilleran region of raised valleys and plains within the western rampart is relatively free from phthisis. So are the western plains under the lee of the Rockies. As the Mississippi is approached the phthisis death-rate increases, and becomes

TABLE LX

Constructed from Solly's "Medical Climatology" and Davidson's "Geographical Pathology."

Female phthisis death-rate per 1,000 known deaths in region, 1880.	Region.	Town.	Town.	
			Rainfall: Inches.	Wind: Annual mean hourly velocity.
	Regions where Phthisis is common.			
197·2	North Atlantic Coast	Boston	46·0	10·9
		New York	45·0	9·4
160·5	Middle Atlantic Coast	Atlantic City	42·9	11·9
		Cape May	47·6	13·4
184·1	Pacific Coast (South Pacific health resorts considered separately, probably many imported cases)	St. Francisco	24·0	9·5
156·8	Region of Northern Lakes	Chicago	35·0	9·6
	Regions where Phthisis is uncommon.			
68·2	Western Plains	Colorado Springs	14·4	9·1
		Denver	14·4	6·8
		Merilla	..	2·3
		Pueblo	12·0	7·4
		Santa Fé	14·6	6·4
		El Paso	9·0	5·5
		San Anthonio	30·6	7·0
85·6	Cordilleran	Salt Lake City	18·9	5·0
		Phœnix	0·7	2·3
		Prescott	16·0	7·0
		Fort Grant	16·8	7·0
		Tucson	12·0	5·0
		Fort Apache	2·0	6·5
		Yuma	3·0	6·0
Rare	Central Mexico	Mexico	24 (under)	2·0
		Guadalajara	34	2·5
	South Pacific Phthisis Health Resorts.			
	Los Angelos	..	18·0	5·1
	Santa Barbara	..	18·0	4·0
	San Diego	..	10·0	5·6

greatest over the Appalachians, and on the Northern and Central Atlantic coast. Florida, in spite of a heavy rainfall and partly Negro population,[1] has a relatively low mortality. The table of wind velocities in America, given in Table LX, has a certain value, although it must be remembered that such *average* estimates take no account of the occasional force of the wind. Thus no indication is given by the figures that the wind on the Pacific coast, although more continuous than on the Atlantic, is weaker[2]—a fact possibly of great importance in respect of its influence on phthisis. Neither does it show the dryness or raininess of the gales. Storm frequency in different parts of the Eastern States, as shown in Map 22, corresponds with the phthisis-mortality distribution to an extent which is at least suggestive. Where storms are rare and rain is heavy, and where storms are frequent but rainfall is light, phthisis is uncommon. Where storms are frequent and rainfall is heavy, phthisis is prevalent. Map 18 shows the same in the case of Italy.

(B) THE SOUTHERLY REGION OF WESTERLY WINDS

The rainfall of this region is generally less than that of the preceding region, and is more apt to occur in sudden deluges, comparatively soon over. It may therefore be said that prevalent strong wet winds are less marked than in the northern region of westerly winds, and it is interesting to observe that phthisis appears to be correspondingly less frequent. It must not, however, be forgotten that the countries in this region are comparatively newly settled.

Australia.—Victoria is more exposed to rainy winds than

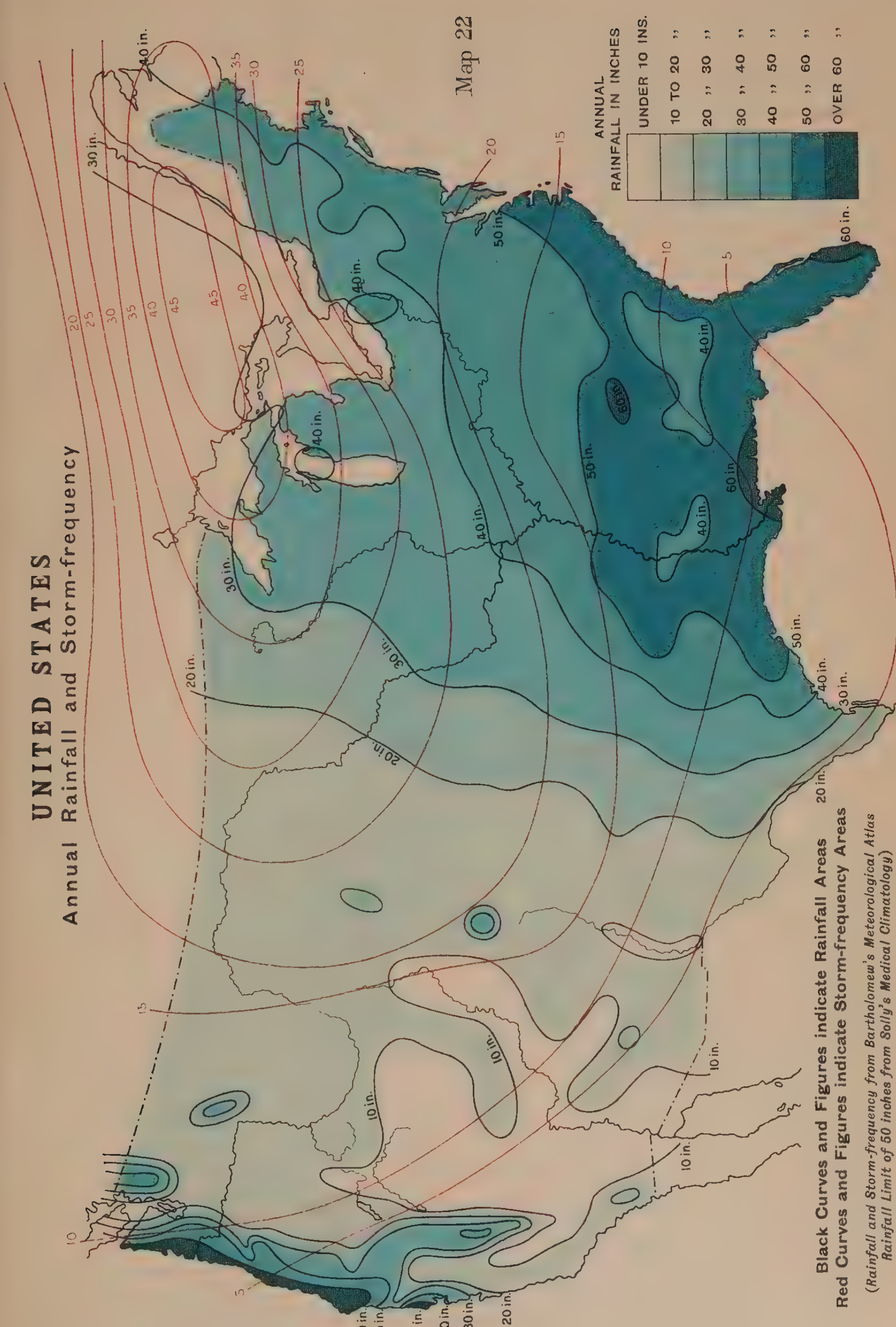
TABLE LXI

Deaths per 1,000 from Phthisis in Victoria, New South Wales, and South Australia, from Dr. Bulstrode's "Milroy Lectures."

	1886 to 1890.	1891 to 1895.	1896 to 1898.
Victoria	1·45	1·33	1·23
South Australia . . .	1·06	0·99	0·87
New South Wales	0·99	0·86	0·79

[1] Longstaff, "Studies in Statistics," plate ix.

[2] Solly, *op. cit.*, p. 311.


UNITED STATES
Annual Rainfall and Storm-frequency
Map 22
ANNUAL RAINFALL IN INCHES
UNDER 10 INS.
10 TO 20 ,,
20 ,, 30 ,,
30 ,, 40 ,,
40 ,, 50 ,,
50 ,, 60 ,,
OVER 60 ,,
Black Curves and Figures indicate Rainfall Areas
Red Curves and Figures indicate Storm-frequency Areas
(Rainfall and Storm-frequency from Bartholomew's Meteorological Atlas
Rainfall Limit of 50 inches from Solly's Medical Climatology)

either New South Wales or South Australia, and has, according to the statistics quoted by Dr. Bulstrode,[1] a higher death-rate. (See Table LXI.)

South Africa.—The prevalent rainy winds for the eastern part of the colony, about which alone I have information, are south-easterly.[2] Along the coasts exposed to this wind phthisis appears to be common.[3] According to Clemow it is "alarmingly prevalent amongst the natives" in Pondoland, Tembuland, and the Transkei, "in spite of their open-air life."[4] Across the mountain range, however, which cuts off the south-east wind from the interior, in the Karoo, in British Bechuanaland, and in the district bordering on the Orange Free State, phthisis is said to be uncommon.[5]

South America.—Under the lee of the Andes in Argentina there is a region very free from rainy winds.[6] Phthisis is said to be uncommon there, although on the coasts of both Chili and Argentina it is prevalent.[7]

(C) REGION OF THE NORTH-EAST TRADE-WINDS

The regions both of north-east and south-east trade-winds unfortunately include few places where satisfactory statistics exist. Deaths are so often uncertified even in towns, mixture of races introduces such confusion, and an apparent tendency of the disease to prevail in coast towns in the Tropics is so general, that safe conclusions can rarely be drawn. I shall, therefore, only refer to those statements which seem to deserve special consideration. The north-east trades blow steadily all the year as moderate breezes. Gales are uncommon. At the sea-level the trade-wind is dry, but rain may be very heavy when the wind is forced upwards by rising land. The region in which the trades continually blow may be said to begin at 25° N. latitude and to extend to the equatorial calm belt.

[1] *Op. cit.*, *Lancet*, August 1, 1903, p. 301, table x.

[2] Hann, *op. cit.*, vol. iii., pp. 354-57, and 363-65. Bartholomew's "Atlas of Meteorology," plate xxvii.

[3] Davidson, *op. cit.*, vol. ii., p. 656. Clemow, *op. cit.*, p. 460.

[4] Clemow, *op. cit.*, p. 460.

[5] Hann, *op. cit.*, vol. iii., p. 374.

[6] Bartholomew's Atlas shows a very low rainfall.

[7] Davidson, *op. cit.*, vol. ii., pp. 983, 975, 976.

This belt begins about 10° N. latitude in our summer, and about 5° N. latitude in our winter, in the East Atlantic, and perhaps in the East Pacific. In the west of both oceans the trade-wind probably blows right up to the Equator.

Abyssinia.—The statement that phthisis is rare on the plateau of Abyssinia has had some stress laid on it.[1] If true, this may perhaps be accounted for by the fact that this plateau is surrounded by high mountains, which must form a considerable wind-screen.

Jamaica.—Davidson states that during 1897 and 1898, whilst the death-rate from phthisis for the whole island was 1·7 per 1,000, the country district of St. Elizabeth, on the south-western coast, sheltered from the trade-wind, had so low a death-rate as 0·09 per 1,000.[2]

Mexico.—The wind movement is very small at the city of Mexico, and the rainfall is moderate.[3] Phthisis amongst Europeans in the surrounding tableland is said to be seldom seen, although it is common on both the Atlantic and Pacific coasts.[4]

British Guiana.—Georgetown, fully exposed to the north-east trade, blowing directly and forcibly on to the coast, with a heavy rainfall,[5] has a heavy death-rate."[6]

Sandwich Islands.—According to Hann,[7] these islands afford "the finest example of the contrast" between a wet and windy side and a dry and sheltered side. I therefore wrote to Dr. Grace of Hilo, who kindly replied, saying it was impossible to provide satisfactory statistics, but that, as regards phthisis, "the fact that the windward is the best side of the islands is well recognised here, though whether that is due to the rain or the wind I cannot say."

(D) REGION OF THE SOUTH-EAST TRADE-WINDS

These are only a little stronger than the north-east. They may be said to blow continually between 25° S. and the

[1] Hirsch, *op. cit.*, vol. iii., p. 206.
[2] Davidson, *op. cit.*, vol. ii., p. 909.
[3] Solly, *op. cit.* p. 456.
[4] Davidson, *op. cit.*, vol. ii., pp. 880, 881.
[5] Hann, *op. cit.*, vol. ii., p. 357.
[6] Davidson, *op. cit.*, vol. ii., p. 933.
[7] Hann, *op. cit.*, vol. i., p. 292.

Equator. In this region lies the famous group of Andean high altitudes, where phthisis is said to be so rare. Quito has a heavy rainfall (some say 70 inches),[1] but it lies in a great valley, the eastern rampart of which must shut out the trade-wind. Jauja and Tarma, in Peru, lie in a "well-sheltered valley."[2] Arequipa, on the western slope of the Andes, has very little wind or rain.[3] La Paz, in Bolivia, has a rainfall of less than 10 inches,[4] and is well sheltered from south-east wind by mountains. On the other hand, phthisis is common all along the Brazilian coast, which is directly exposed to the trade-wind and has a heavy rainfall.[5]

(E) THE SO-CALLED EQUATORIAL CALM BELT

This belt appears to be well marked in the East Atlantic Ocean. Along the Gold Coast, according to Dr. W. T. Prout, phthisis is not common.[6] In the colony of Lagos I have learnt, through the kindness of the late Governor, Sir William Macgregor, who had a special inquiry made for me, that it is rare.[7] For the rainy part of the year both colonies lie within the belt of equatorial calms and light, variable winds. The season, in which the colonies are outside this belt, is dry. All the year round a south-west wind makes itself felt,[8] but this appears to be only a gentle breeze.

SO-CALLED "CALM BELTS" OF CANCER AND CAPRICORN

There seems a great deal of evidence that between the latitudes of 25° and 35° N. and S. a belt of calms and light variable winds about 5° broad encircles the globe and moves to and fro with the seasons. Between 30° and 35° N. and S. the year is divided between this calm belt and the westerly winds, and the latter probably so far neutralise the effect of the former that for the present purpose this part of each belt may be placed (as has been done) in the regions of westerly winds. But between 25° and 30° N. and S. the calm belt alternates with the gentle trade-winds, and these

[1] Solly, *op. cit.*, pp. 370-71. [2] *Ibid.*, p. 373. [3] *Ibid.*, p. 372.
[4] Bartholomew's "Atlas of Meteorology," plate xviii.
[5] Davidson, *op. cit.*, vol. ii., p. 963. [6] *Ibid.*, p. 634.
[7] Private Letter. [8] Hann, *op. cit.*, vol. ii., pp. 22, 70, and 71.

latitudes ought to be characterised by relatively less phthisis owing to relative rarity of rainy wind. Moreover, the calm belts are mostly dry belts, which should make the relative rarity of phthisis even more probable. In the southern hemisphere the belt of Capricorn runs more or less horizontally round the earth, but in the northern hemisphere the continent of Asia is said to draw the belt of Cancer locally somewhat farther north. It will, I think, be seen that a very remarkable correspondence between these belts and low phthisis death-rate exists in those countries where it can be investigated.

(F) THE "CALM BELT" OF CANCER

Florida and a small strip of the *Gulf Coast of North America* have been shown to have a low phthisis death-rate, in spite of a largely Negro population and a heavy rainfall. The *Canaries* have a lower death-rate than any part of Spain, *viz.* 0·7 per 1,000.[1] *Egypt between Cairo and Assouan* is nearly free from phthisis.[2] Farther east the position of the belt becomes uncertain.

(G) THE "CALM BELT" OF CAPRICORN

South Africa.—British Bechuanaland, the Orange Free State, Basutoland, and part of the Transvaal, in all of which phthisis is almost unknown,[3] as well as Zululand and Natal, in which it is uncommon,[4] lie between 25° and 30°.

Australia.—The Darling Downs of Queensland, where phthisis appears only rarely to originate, lie within the belt. They are remarkable for the absence even of the hot winds which other parts of the interior experience.

THE FARÖES, THE FALKLANDS, AND ICELAND

Lastly, there are three countries which have been grouped together and said to constitute a strong objection to the

[1] Taylor, *op. cit.*, p. 63. [2] Clemow, *op. cit.*, p. 458. [3] *Ibid.*, p. 461.
[4] J. F. Allen : "Transactions of the British Congress on Tuberculosis," vol. iii., pp. 39, 50.

conclusions as regards rainy wind and phthisis arrived at elsewhere, *viz.* the Faröes, the Falklands, and Iceland.

Of these, the *Faröes* have, Dr. Rördam informs me, not a low mortality from phthisis, as has been supposed, but one probably as high as Denmark generally.[1]

The *Falklands*, where phthisis has been said to be very rare, have a low rainfall—only about 20 inches ; the prevailing winds are westerly at all seasons (see Table LXII)[2] and the

TABLE LXII

Frequency of Winds in the Falkland Islands (*Hann*)

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calms
Spring and Summer .	9·6	6·3	5·3	8·0	24·7	52·0	46·7	25·7	2·7
Autumn and Winter .	14·0	4·0	7·0	3·7	13·3	30·0	61·7	37·0	13·0

inhabitants have built their dwellings almost everywhere in shelter, as can be seen from the Government Survey map. Stanley, the only town, is built on the shores of a land-locked inlet, sheltered from every wind.

Iceland, where phthisis is said to be uncommon, has a moderate rainfall of about 28 inches in its western parts, from which the statements come relating to phthisis rarity, where the capital lies and where the bulk of the population appear to dwell. The prevailing winds are from the east (see Table LXIII)[3] and having to cross the high tableland

TABLE LXIII

Frequency of Winds in Reykjavik and Stykkisholm, Iceland (*Hann*)

	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
Winter . .	9	25	22	12	9	17	4	2
Summer . .	12	13	20	13	11	11	8	12
Year . .	12	19	22	13	10	13	5	6

of the centre of the island are dried and broken when they descend to the western coast.

[1] Private letter. [2] Hann, *op. cit.*, vol. iii., pp. 466–67. [3] *Ibid.*, pp. 491–97.

Thus, in none of these three instances can it be said that prevalent strong rainy wind co-exists with rarity of phthisis, and the objection based on them does not hold.

Summary of the Foregoing

In all these different parts of the globe, therefore, prevalence of strong rainy winds appears to be remarkably associated with increased prevalence of phthisis, whilst absence of such winds seems to correspond strikingly with rarity of phthisis. Information of much interest from other quarters has not seemed sufficiently definite to advance as argument. None has been received which conflicts with the general conclusion just stated.

CHAPTER VII

CONCLUSION

In all these successive investigations the same result has been arrived at—apparently unavoidably. The law which seemed suggested by a comparison of the rural districts of Devonshire was found to hold true for the parishes of each of four separate rural districts specially chosen as suitable; and to hold true conspicuously, in spite of the liability of the small figures to introduce confusion, in spite of different soils, different rainfalls, different periods of observation.

After it had been pointed out that female death-rates would form a safer basis of inquiry, subsequent work, done with female death-rates alone, gave a result even more striking than had been obtained with the mixed death-rates. A specially suitable district with almost uniform soil, equidistant from the sea in every direction except the north-east, showed, for the ten years 1890 to 1899, a death-rate amongst its parishes exposed to west and south-west winds, nearly five times as great as amongst its sheltered parishes.

Again, the streets of Exeter showed, for the ten years 1892 to 1901, a general female phthisis death-rate in those streets whose roadways were exposed to south-west, west, or north-west winds, almost twice as great as that in the streets sheltered from these winds. Not only so, but when only streets on similar soils were compared with each other, the same result came out, the ratio remaining almost two to one on clay, but becoming more than two to one on sandstone, and more than three to one on gravel (made soil, whose composition is, of course, inconstant, forming the sole exception). Further, where only streets with similar rateable house values were compared, at every separate value a preponderance of about two to one was maintained; and finally, when specially sheltered streets were compared with

specially exposed streets, the influence of soil being eliminated by only considering streets on clay, the phthisis death-rate in the exposed streets was found to be almost four times as great as that in the sheltered streets, or, if due allowance was made for differences in rateable values, more than four times as great.

But it had been objected that ten years—the period taken by Sir George Buchanan and by Haviland—was too short a period for observation. The phthisis mortality was thereupon again investigated in twenty-three parishes of North Devon during the forty-five years, 1860 to 1904, these parishes being situated in a specially suitable district, well known to the investigators, presenting well-defined exposures and shelters to the winds in question, with well-ascertained geology and with careful wind and rain observations. Not only was the same law found traceable for the whole period of forty-five years, in spite of the fact that the most sheltered parishes were generally on less pervious soil and under a heavier rainfall than the most exposed, but every successive quinquennial period showed it except the first, and, when only the last twenty years were considered (in which Koch's discovery had become generally known and diagnosis had probably become more precise in consequence), the preponderance grew much more striking. Lastly, when only the ten years 1890 to 1899 were taken into account (during which the rainfall was lower and the north-west wind less frequent) the difference between the death-rates in the parishes exposed to south-west, west, and north-west winds and in those exposed only to north-west winds became three to one, whilst in the parishes sheltered from all three winds, actually no phthisis deaths occurred at all.

Up to this point observations had been made only on a small scale, and only within the limits of a single English county. But it was necessary to trace the law all over the world, so far as that was possible, in order to determine whether the relations of phthisis death-rate to the prevalence of strong rain-bearing winds are the same elsewhere as they had been found to be in Devonshire. It will be remembered that it was just such a test that indicated the weakness of the altitude theory. Yet in this case there was found, in all quarters of the globe, extraordinary confirmation of the

conclusions come to at home. Not only so, but difficulties hitherto unexplained—Buchanan's "exceptions" in the south-eastern counties of England, Davidson's difficulties respecting the phthisis distribution of England and Wales, the curious western belt of heavier death-rate in Northern Germany, and (perhaps) the odd middle belt of higher death-rate in the Swiss Alps—for the first time received a reasonable explanation.

I am not aware of such a mass of evidence in favour of any climatological theory, with so many precautions taken to safeguard the result from error. It remains to be seen what objections have been raised against it and what will be the consequences if it should be considered to be established.

There have been two classes of objections, the first impugning the theory altogether, the second accepting it but assigning certain explanations of it. To the first class, *viz.* the objections respecting the size of the populations, the period of observation, the consideration of the mixed sexes, possible errors introduced by differences in occupation, sanitation, closeness of intermarriage, and race, sufficient reply has been given in the work which has been recorded. To the second class perhaps an answer is of less consequence, but nevertheless an answer is not wanting: in Exeter streets the explanation that wind simply drives wet into the walls has been shown to be insufficient, and the explanation that the wind only exerts its influence by compelling the closure of doors and windows against it, overlooks the fact that doors and windows are frequently on the sheltered sides of the houses. These explanations may be part of the truth. They are not, I feel sure, even when taken together, by any means the whole truth. Neither of them, it should be remembered, has a vestige of evidence to support it. The work in Exeter streets makes it highly probable that, to a large extent at all events, the influence of wind is direct and is exerted on the persons exposed to it.

But whatever the explanation may be, the consequences, as regards other supposed influences, are the same. The influence of wind has been incidentally shown to be more powerful than the influence of soil, of altitude, and even, in some places, of density of population. This means that, if the influence of rain-bearing wind be accepted as a fact, all

that has been written on these other influences, without reference to it, will have to be reconsidered. Already the results of such a revision are beginning to emerge; the influence of soil, hitherto disputed, seems likely to be shown at least as important as Buchanan thought it to be; but the effect of altitude, *per se*, on the prevalence of the disease, seems likely to be proved to be relatively small, if indeed it be not actually non-existent.

In conclusion I would ask for a careful consideration of the facts I have brought forward, with due regard to the difficulties of the work. Where a mistake has been made I have taken care to indicate it. In assessing shelters and exposures—a task, it will be readily understood, which is not always an easy one—I have, when possible, availed myself of the criticism of others intimately acquainted with the area in question. Personally I cannot see how such a mass of evidence, so sifted, yet so constant in its indications, can be set aside as fallacious.

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